POWER

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Modern Materialism

UNDER the caption "Progress and Power" a writer in the *Foxboro* (Mass.) *Reporter* takes me to task because in a recent paper I commented upon how much civilization is indebted to mechanical power.

He asks if I think that modern industry is "progress" over the craftsmanship of the past and wishes that John Ruskin were alive to flay me on this point.

"Since the inauguration of the machine age," he says, "we have made no contribution to civilization and culture that can begin to equal the arts and crafts, the literature and music of the ages that knew neither steam nor electricity."

I appreciate the difference between the artisan and the man who simply performs a repetitory process with no idea, perhaps, of what part his product plays in the finished article.

And I am for the artisan, with his special skill, his intelligent interest in his work and his masterly pride in his product.

There is a lot of opportunity for him yet, and a lot of work turned out that lacks his honest interest and painstaking effort.

But I wonder if a craftsman cannot do just as good a job on a lathe or mortising machine as he could with hand tools.

And I wonder if the esthetic excellence of his product is impaired if the energy of running the machine is furnished by a motor instead of by the muscles of his legs.

We may not be turning out Shakesperes and Miltons, and Beethovens and Michelangelos at a rate that should be expected from the advanced material condition of the race. It may be, as he says, that "There is nothing to quicken the impulses, nothing to inspire the soul, nothing to warm the heart in a civilization that has its being in mere power."

But is there anything in the advantages and conveniences that power has produced to discourage genius and the artistic spirit?

Certainly, more people have the education and leisure and means to enjoy and more ready access to good literature and art and music than when the work of the world was done by human muscle and the achievements of talent and genius were, from lack of cheap reproduction and distribution facilities, available only to the few.

Plenteous power is not holding back intellectual and spiritual development and wide participation in its products.

F. R. Low

Steam and Electric Service in Detroit's Largest Hotel

IN DETROIT'S largest hotel, the Book-Cadillac, after careful analysis of the various services, including light and power, ventilation, steam for laundry and cooking, refrigeration, compressed air, etc., boilers were installed to supply the heat, electrical energy was purchased and for various services both steam and motor-driven machines were provided, so that exhaust would be available in winter and motor-driven machines used in summer.

BUILT on the site of the old Cadillac, the new Book-Cadillac is the last word in hotel construction. It is 32 stories high above ground level and has three stories below grade. The building has 1,200 guest rooms, occupies about two-thirds of one city block and has frontage on two streets approximately 151 and 220 ft.

In determining the character and layout of the mechanical equipment for the hotel, Newell J. Hill, consulting engineer, deemed it necessary to consider four different methods or combinations of steam and electric service. The Detroit Edison Company had only low-pressure steam to offer and 4,600-volt three-phase 60-cycle primary current. It was considered desirable to provide high-pressure steam for the laundry and kitchen in order to insure fast service and good operating conditions in these departments. Another thing that had to be considered was the possibility of using fuel oil under the boilers as against the use of coal with stokers.

With these things in mind the first plan of operation suggested was to provide a boiler plant to generate high-pressure steam for the laundry and kitchen and to purchase low-pressure steam for hot water and heating and primary current for lighting and power.

The second plan was to provide a boiler plant to generate high-pressure steam for laundry, kitchen and hot water and for driving auxiliary refrigeration and air compressors during the off-heating season as required, but to buy steam for heating and primary electricity for power and light.

The third plan was to install a boiler plant of sufficient capacity to supply steam for every purpose with the arrangement used in the second plan elaborated so as to provide steam-driven auxiliaries on refrigeration and air compressors, water supply pumps, stoker fans, etc., so that during the heating season all exhaust steam could be utilized, but to purchase primary current for light and power.

The fourth plan considered was to provide a central power plant that would supply all high- and low-pressure steam and electricity for light and power. On the basis of coal delivered at $7 per ton in the bunkers and oil delivered at 8½c. per gallon in tanks at the building, and with other items at the rates prevailing in the summer of 1923, the comparison in percentage of costs of yearly operation was estimated to be as in the accompanying table. Actual estimated costs are not available, but the comparison is made in percentages that will indicate the relative values of the various plans considered. The poor showing made by oil is due to the high cost of this fuel at the time in Detroit. The percentages, of course, would vary with the price per gallon, and in this there has been considerable change during the last three years.

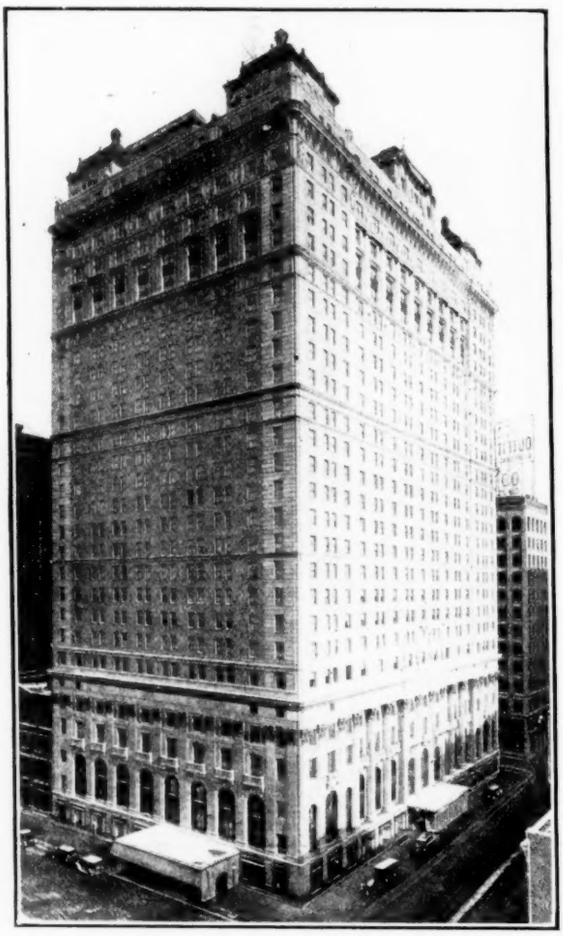


Fig. 1—Book-Cadillac Hotel, Detroit

In view of this report of estimated costs, it was decided to adopt the third plan, and the results of actual operating conditions have been found to approximate closely the estimates made.

The power plant was designed primarily as a heating plant for the hotel. A large percentage of the auxiliaries are in duplicate, one steam and one electrically driven, so that the steam-driven equipment may be used largely during the heating season

and the electrically driven machines during the summer. As is usual, the major portion of the mechanical equipment is below ground. The third basement contains boiler, pump and heater rooms and the sub-basement is occupied largely by the refrigerating plant, where are located compressor machinery, brine storage or freezing tanks, ice storage rooms, machine shop, steamfitting and plumbing shop, electrical department, carpentry and paint shops.

In the boiler room are three 4,160-sq.ft. cross-drum boilers operated at a steam pressure of 150 lb. and fired by lateral-retort underfeed stokers. Each boiler is designed to operate at 200 per cent of rating, so that the plant has capacity to generate approximately 85,000 lb. of steam per hour. Duplicate fan units are installed, one driven by a vertical engine and the other by a motor, to supply the forced draft for the stokers.

Coal is purchased in the local markets and delivered daily to the hotel by truck, from which it is dumped into bunkers below the alley level and from there passed through a weigh larry to the stoker hoppers. The bunkers have been calibrated so that an accurate check on weights and consumption may be maintained. The bunkers are inventoried on the first and fifteenth of each month and in this check of dealer weights against volumetric measurements there has been little discrepancy. The storage capacity is about 280 tons, or ordinarily one week's supply during severe winter weather.

Ashes are wheeled from the furnaces to an ash elevator in which they are lifted hydraulically three stories to a tank just below the ground level. Arrangements have been made whereby the ash from storage can again be delivered by the same hydraulic lift to a point above the alley level for discharge directly into trucks.

Water is supplied to the hotel through two 10-in. mains, each source of supply to the building being individual, so that in case of accident to a portion of the city mains no total interruption of water service to the building would be experienced. The water used in refrigeration passes through the condensers to surge tanks in the sub-basement and from there is drawn by the house pumps as required by the building, any deficit being made up from the city mains through float-valve control. Little or no water is wasted during the major part of each year, although during the summer months, when both 100-ton refrigerating units are operating at capacity, there is an excess of water, owing to the fact that the quantity required by the condensers is greater than that used in the hotel, particularly during the night periods. The excess is wasted to the sewer by the surge tanks automatically overflowing.

The water supply for the boilers is passed through a closed heater by either one of two steam-driven pumps. Hot-water requirements for various purposes are cared for by five closed heaters of the capacities given in the table of equipment. These heaters are thermostatically controlled so as to maintain the required temperatures, and an elaborate water-circulating system has been provided so that there will be little difference in the temperature of the water at the points of distribution and supply.

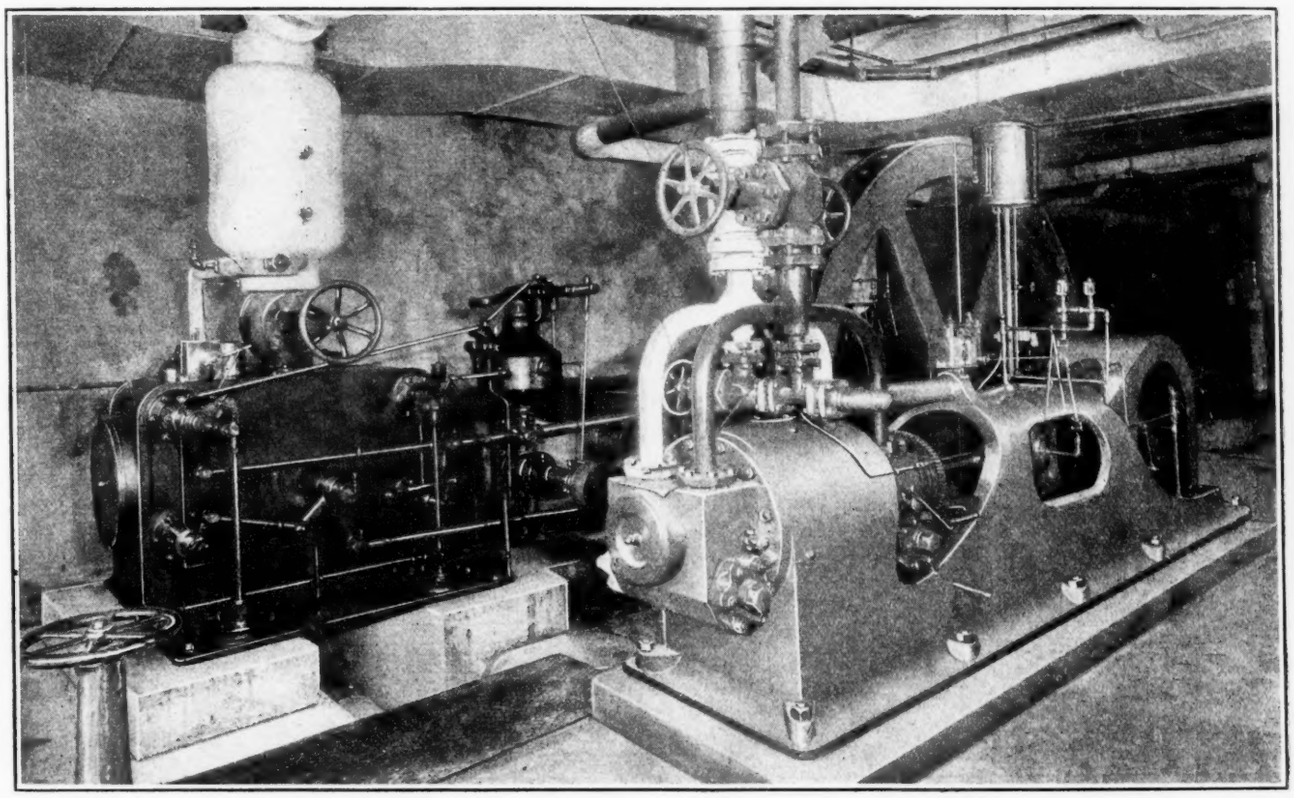


Fig. 2—CO_2 compressor of 100 tons capacity driven by Corliss engine

COMPARATIVE YEARLY OPERATING COSTS

Scheme	Using Coal, Per Cent	Using Oil, Per Cent
1	100.0	107.1
2	90.5	104.0
3	88.5	111.1
4	94.0	134.0

Refrigeration for ice making, refrigerators and for air cooling, is supplied by two 100-ton CO_2 compressors, one driven by a Corliss engine and the other by a synchronous motor. The engine is equipped with a variable-speed governor so that this unit may be operated continuously at such speed as to correspond with the required refrigerating load.

As is customary where space is limited and the water supply good, a double-pipe condenser has been used. In this apparatus the number of joints has been limited to a minimum by welding except where valves and special fittings are bolted to flanges. In the low-pressure end of the refrigerating plant the brine system is in use. Brine is circulated to 28 refrigerators in various parts of the hotel. For making ice there is a 124-can brine tank with a capacity of 20 tons of ice per twenty-four hours. In the ice storage the temperature is kept below freezing by brine circulation through coils. The refrigerating capacity of the brine system is 85 tons, and the other 15 tons of the unit capacity is used for cooling drinking water for the various rooms throughout the hotel by direct expansion.

The motor-driven refrigerating machine is used to cool air for the public rooms of the hotel. The CO_2 liquid is expanded into coils located in a large water tank known as a Baudlet cooler. From the tank the water is pumped to air washers located on the sixth floor in connection with the ventilating units, so that chilled water is used to refrigerate air during the summer months. This water returns to the cooler by overflowing at the washer chamber down a return line. Piping arrangements have been made so that either machine can be operated on either service.

The refrigerated air is supplied at a temperature of approximately 8 deg. below outside temperature. The humidity is controlled and incidentally the air is cleaned in the same washer during the heating season, so that no air enters the public rooms during any period of the year without passing through a water spray.

Air service at 65-lb. pressure is supplied by two air compressors, and as is the case with the refrigerating units, one machine is motor-driven at constant speed and the other engine driven at a speed varied to meet the requirements.

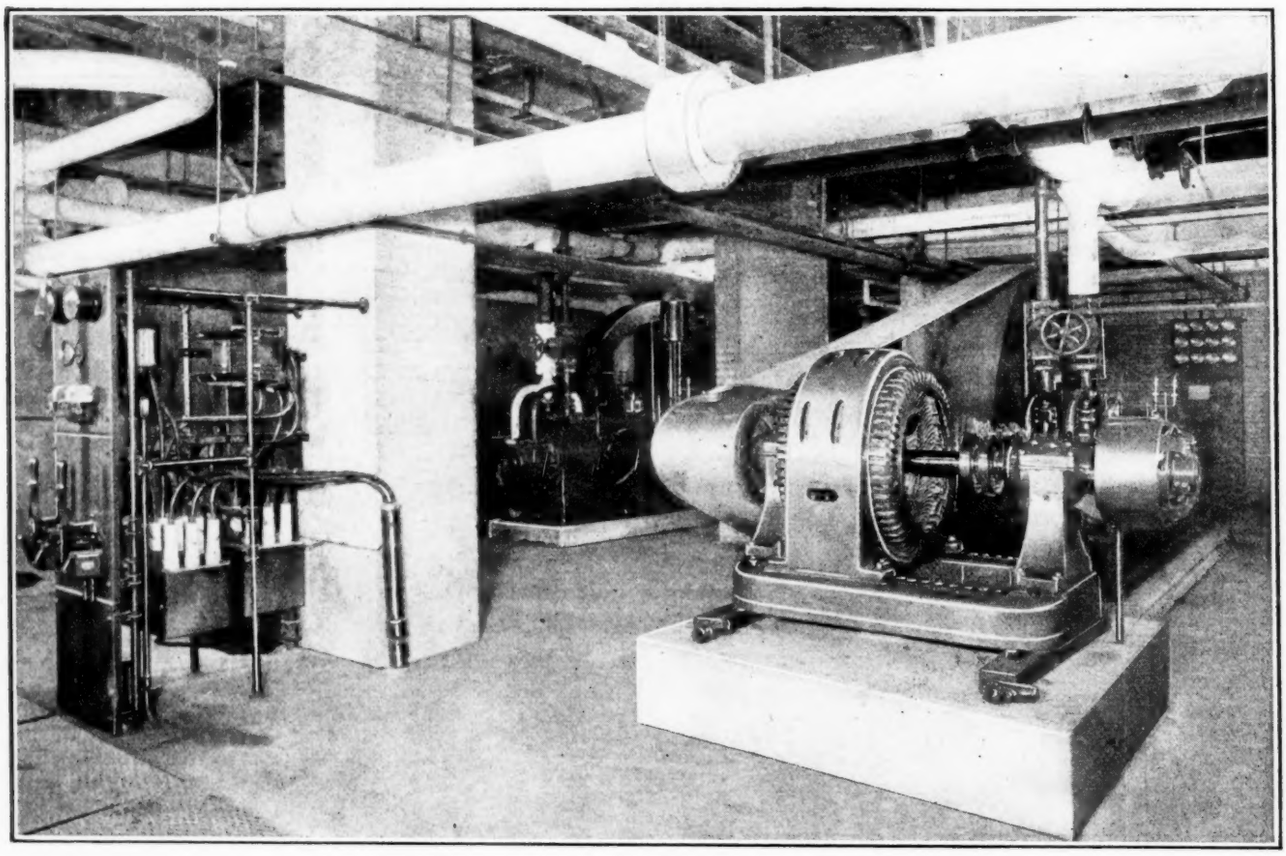


Fig. 3—Synchronous-motor-driven carbon-dioxide compressor

For fire protection sprinkler equipment has been provided in all portions of the building where there is any great amount of hazard, and the system is fed from the water service tanks at the top of the building. As an emergency unit a turbine-driven centrifugal pump of 1,050 gal. per min. capacity has been provided.

As previously intimated, the electrical energy for the building is purchased from the local power company, the high-tension current being supplied by two lines at 4,600 volts directly from two separate stations. These lines are tied together in the primary room of the hotel, and from there the current flows through buses to oil switches and on to transformers which reduce the voltage to 220 for power purposes and 110 for lights. Two of the transformers reduce the voltage to the desired point for use through rotary converters, by which means direct current is made available for variable-speed fans and other uses in the building. In addition to the

rotary converters, which are of 200 kw. capacity, an emergency direct-current line has been installed for use in case of a total interruption to alternating-current service or an accident to the rotary converter.

A unique feature concerning the reliability of lighting for the building is the fact that reverse cut-over automatic switches have been installed, so that in case of interruption to the alternating-current lighting supply, the switches will automatically cut in on emergency, night light, and stairway circuits to the direct-current emergency line. When the alternating-current supply has been restored, these switches automatically cut back on to the former supply lines, placing the service again on alternating current.

For passenger service there are six elevators, each of 2,500 lb. capacity, equipped with the unit Ward-Leonard control system and telephone service and operated at 750 ft. per min. The lift of these cars is approximately 360 ft. Boardman signal control equipment regulates the timing and spacing of the cars.

One freight and four service cars supply the needs of room service, the handling of trunks and other materials. They have Ward-Leonard control and operate at a speed of 600 ft. per min. The capacity of each service car is 2,700 lb. and of the freight elevator, 4,500 lb. In addition, there are three hydraulic lifts, one for handling trunks, another serving as a means of conveyance for heavy material and the third elevating the ashes from the boiler room to the alley level.

A point of interest is that each electrical elevator has its own motor-generator set, the alternating current being taken from the switchboard room in the sub-

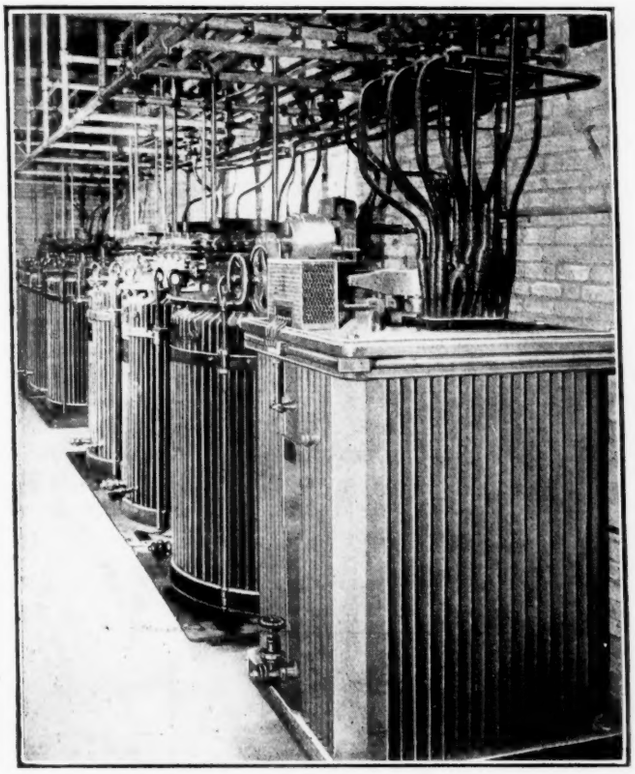


Fig. 4—Transformer room in the hotel

PRINCIPAL EQUIPMENT OF BOOK-CADILLAC HOTEL POWER PLANT

BOILERS AND AUXILIARIES

Boilers, 3 cross-drum	Heine Boiler Co.
Steam-making surface, sq.ft.	4,160
Working pressure, lb. gage	150
Superheat, deg. F.	None
Furnace volume, cu.ft.	1,347
Furnace volume per sq.ft. of h.s., cu.ft.	0.316
Grate surface, sq.ft.	71.25
Firebrick	Walsh Fire Clay Products Co.
Stokers, 3 Jones lateral retort	Riley Stoker Corp.
Forced-draft fans, two	American Blower Co.
Drive	One 9 x 8-in. engine, one d.c. motor, 39 to 45 hp., 355 to 385 r.p.m.
Stack, steel, 5 to 8 ft. diam., 412 ft. high	Union City Iron Works
Incinerator, 6 ton	Goder Incinerator Co.
Steam-flow meter	Bailey Meter Co.
Draft gages, 3 multi-pointer	Bailey Meter Co.
Recording thermometers	Foxboro Co., Inc.

PUMPS

Boiler feed, 2 duplex, 10x6x12-in	Worthington Pump & Mach. Corp.
Vacuum, simplex, 10x12x14-in	Worthington Pump & Mach. Corp.
Service, 2 cent., 800-g.p.m. against 400-ft. head	Pennsylvania Pump and Compressor Co.
Drive, one 130-hp., 2,200 r.p.m. turbine and one 130-hp. motor	Westinghouse Elec. & Mfg. Co.
Service, 2 cent., 400 g.p.m. against 125 ft. head	Pennsylvania Pump & Compressor Co.
Drive, one 20 hp., 2,000 r.p.m. turbine and one 20-hp. motor	Westinghouse Elec. & Mfg. Co.
Fire pump, one 750-g.p.m. against 462 ft. head	Dayton-Dowd Company
Drive, 150-hp. turbine, 2,000 r.p.m.	Westinghouse Elec. & Mfg. Co.
Sump pumps, vertical, 200 g.p.m.	Yeomans Bros. Co.
Drinking-water pumps, 100 g.p.m., 60-ft. head, 1,720 r.p.m.	Pennsylvania Pump & Compressor Co.
Ejectors, two, 233 g.p.m.	Yeomans Bros. Co.

HEATERS

Feed water, one closed, 25,000 lb. per hr.	Patterson-Kelley Co.
Service water 5 closed, 3,000 to 8,000 g.p.m.	Patterson-Kelley Co.

AIR COMPRESSORS

Two of 228 c.f.m. capacity	Pennsylvania Pump & Compressor Co.
Air pressure, lb.	65
Drive, one engine and one syn. motor, direct connected	Electric Machinery Co.

REFRIGERATION

Two CO_2 compressors, 100-ton, 6½x24 in.	American Carbonic Mach. Co.
Drive, one Corliss engine, 18x36-in.	Allis-Chalmers Mfg. Co.
Drive, one synchronous motor, 160 hp.	Electric Machinery Co.
One 10-ton, 3½x11½-in.	American Carbonic Mach. Co.
Ice tank, 120 cans, 300 lb., 20 tons per 24 hr.	American Carbonic Mach. Co.
Condenser, double-pipe	American Carbonic Mach. Co.
Refrigerators, 38	Dry-Kold Refrigerator Co.

HEATING AND VENTILATION

Heating systems, contractor	Baker, Smith & Co.
Fans, 25 (1,600 to 59,000 c.f.m.)	American Blower Co.
Drives	Motors, direct and belt connected
Air-washer system	American Blower Co.
Temperature control	Johnson Service Co.
Air filters	Midwest Air Filters, Inc.

ELEVATORS

Manufacturer	Otis Elevator Co.
Control	Unit Ward-Leonard system
Passenger	Six, 2,500 lb., 750 ft. per min.
House service	Four, 2,700 lb., 600 ft. per min.
Freight	One, 4,500 lb., 350 ft. per min.
Doors and car gates	Tyler Door Co.
Door controls	Graham Norton Pneumatic Door Closer Co.

ELECTRICAL EQUIPMENT

Rotary converters, 200 kw.	Ridgway Dynamo & Engine Co.
Transformers, eight 200 kva., two 100 kva.	Pittsburgh Transformer Co.
Voltage regulator	Westinghouse Elec. & Mfg. Co.
Switchboard	Frank Adams Company
Meters	Sangamo Electric Company
Circuit breakers	Condit Electrical Mfg. Co.

MISCELLANEOUS

Flush valves	Sloan Valve Co.
Vacuum cleaning	Spencer Turbine Co.
Pneumatic tube system	The Lamson Co.

basement direct to the penthouse and there converted to direct current.

For heating, both direct and indirect radiation are in use, the direct surface being used entirely in bedrooms and to some extent in the public rooms. The indirect portion of the system is used throughout the public rooms and is the means by which humidity and temperature to some extent are controlled during the winter months and the air refrigerated during the summer months by using chilled water instead of the washer water.

Steam for the heating system is supplied primarily by the exhaust from the steam-using equipment throughout the plant. Live steam through reducing valves supplements this supply as required. In the public rooms the temperature is controlled by thermostatic regulators which operate silphon valves connected in the steam lines to the vento coils of the indirect heating units. The total air-handling capacity of the ventilating fans is approximately 500,000 cu.ft. of free air per minute. Individual fans have been installed for the major and important requirements, so that temperatures may be varied in certain portions of the building as required. The ventilating facilities for the laundry are of such capacity as to change the entire volume of air every three minutes, so that the temperature here during the summer months is seldom more than three degrees above the outside temperature. A separate exhaust fan has been installed for the boiler room, which keeps the temperatures at the floor level of this room at approximately 5 to 8 deg. above outside temperatures during the summer. As a result the entire power plant is one of the best basement-ventilated plants known, for at no time is the air at a temperature more than eight degrees above that of the outside air.

The foregoing information was obtained from an article going into more elaborate detail on all departments of the plant, prepared by Edgar A. Sitter, chief engineer, and S. L. Potts, instructor in steam engineering, at the Cass Technical Schools. The analysis relative to the type of plant came from Newell J. Hill, who had been retained as consulting engineer.

Use of Plastic Refractories in Boiler Furnaces

By HUGH E. WEIGHTMAN
Consulting Fuel Engineer, St. Louis, Mo.

Practical hints on the use of plastic refractories, the construction of walls and arches, instructions on initial firing and cooling, characteristics of various plastics, and the cost and service compared to brick.

PLASTIC refractory, or, as it is often termed, plastic firebrick, is a composition quite well known among boiler-plant operators for its use in building furnace walls and for patching. As the material appears on the market, it is generally in one of two forms, dry or wet. The dry plastic is much the same as the wet plastic so far as composition goes, the difference being that the dry material is marketed with only the natural moisture of the dry product, whereas, water is added to the wet plastic until it has the proper consistency, as in the manufacture of "stiff mud" brick. During the last few years the use of this material has become sufficiently standardized so that dry plastics are furnished usually in 100-lb. sacks and the wet plastic in 500- to 650-lb. barrels or drums. There are some 70 brands of this material on the market today, some good, others poor.

In purchasing material of this kind the reputation and experience of the manufacturer will have to be taken as a guide to the value of the product, unless the purchaser is equipped with apparatus and a personnel to make the proper tests. In an investigation of various of these products it was found that some were manufactured from available plastic fireclays and waste brick. While such products are adequate for minor installations, the presence of slagged portions of the waste brick often renders the material unreliable. It at least was found to render duplication of results difficult if not impossible. Other products were found to be outlets for the culls from the manufacture of brick. Such culls are produced in greater quantities now on account of the demand of the furnace builder for closer dimensioned brick. Using them as grog is satisfactory when the materials are properly compounded.

If the material is to be stored in places subject to freezing, it is best to use it dry, since it is always ready to be worked into a plastic. The freezing usually does no harm to the wet product, except when certain binders are used, but makes thawing necessary when getting it ready for use. Thawing is a slow process, as water may not be added to the product. If rightly compounded, a dry plastic may be made ready for use by a simple process even in the absence of mixing equipment. Turning the material over while adding water, as in mixing concrete, is hard labor and subject to the danger of getting too much water into the product. The easier and better way is to spread a layer 2 to 4 in. thick on the floor or mixing board. Sprinkle this lightly with water. Then add another layer of material and repeat. When the pile has been built up, cover it with wet burlap bags, keeping the bags wet for a week or ten days. This process will bring out the best plastic properties with the least amount of water. Thoroughness of sprinkling and time are the principal factors.

Construction of Walls

Assuming that the material is of the proper consistency, the following suggestions will apply to all side walls and solid structures, regardless of the make of plastic. Before starting the structure, forms should be built. Plastic walls have been built without adequate

forms, and some plastics are made with too little plastic clay for the purpose of making the material as solid as possible. However, cracks are sure to develop in drying if rigid forms are not used, as sufficient pounding cannot be done to insure against lamination of the product. Rough lumber forms are better than dressed lumber on account of the slightly greater rigidity and the increased absorption of the undressed surface. The thickness of the forms will depend on the distance between supports. If thin forms are used, more bracing will be necessary. Heavy forms with fewer braces will be found superior to light forms with a multitude of braces, both on account of greater stability and freedom in working around the forms. Hard dense lumber should be avoided, as such material will not absorb the moisture, thus delaying the drying. Lumber to be used in making forms should be stored in the plant where it will remain dry. Bolted forms of a rigid nature may be constructed where many furnaces are to be prepared. Such forms are removed and saved after the initial drying period, just before firing up. Forms for supporting doors and arches are best burned away in firing.

Rigid Foundations Necessary

Foundations under plastic built walls must be rigid. Often the walls are built on poor foundations, with the result that cracks develop after drying and sometimes only after firing. Examination will show whether these cracks are due to poor foundations or improper materials. The foundation should be level, or if pitched, it should slope away from the furnace interior.

Corners of continuous walls should be reinforced with an additional thickness of plastic; usually about 2 in. will be sufficient for the usual walls of 9 to 18 in. thickness. To forget this is to invite cracks at the corners of the walls.

After the forms have been removed, the firing should be begun at once and adhered to if good results are to be expected. It has been the writer's practice to remove the forms and slightly wash the walls with a thin batter of clay in water or some of the plastic clay from the mixture used in making the walls. This gives a skin coat that is of benefit in preventing slag trouble. This same treatment prevents the skin surface drying out too rapidly in the initial firing, thus preventing the scaling of the surface often noticed in such work. The skin thus formed does not hinder the liberation of moisture, as this may freely vent toward the outer wall.

Construction of Suspended Parts

With careful workmanship arches may be constructed of plastic materials. The work is fraught with danger, so the greater care is needed. Owing to the slightly lower modulus of rupture, greater reinforcement is needed than for ready-burned clay products. This extra reinforcement may be added to the suspended arch steelwork in the form of a wire mesh. Before placing the mesh, coat all steelwork and the mesh as well with a good covering of sodium-silicate. The sodium-silicate chosen should be one that dries rapidly with a tight skinlike coat on steel. If the available silicate does not act well in this regard, try adding a slight amount of fine fireclay to the mixture. The material then should be thinned with water to a free brushing consistency. Put on only the thinnest coat that can be applied. This treatment will cause the plastic to adhere to the steel.

Build solid forms under the reinforcement. Spray the upper side of the forms with a thin slurry of clay. In this slurry do not use silicate or other binders, merely water. After this shred the plastic in such a manner as to be able to pack it into the reinforcement. After placing a small layer, pack it down thoroughly with a mallet. Continue in this way until the arch is of full thickness. After pounding a layer solid and before starting to place the next layer, be sure the surface is rough. A smooth surface will result in laminations in the work. For this reason, in all plastic work the use of steel tools is to be avoided. After the final layer has been pounded in place, it is well to pound the entire arch with a heavy wooden tamp. In firing, burn the form down. In no case should it be removed for firing.

Initial Firing of Plastic Walls

The wrong method of firing a plastic job will ruin the finest workmanship. In firing plastic linings in boiler furnaces, it is as necessary to follow the experience of ceramic plants as for burning firebrick. Besides, there is an additional hazard not often considered. In burning brick, the entire piece is bathed in the heat of firing. With plastic furnace walls, on the contrary, the firing is done only from one side. This has a tendency to warp the wall, for if the heat is raised too rapidly, the difference in temperature between the inner and outer parts of the wall will become great enough even to rupture the wall. The thicker the wall or the poorer the material is as a conductor, the slower the rise in temperature allowable in firing. A temperature gradient of 900 to 1,000 deg. F. across an inch of wall is sufficient to disrupt the wall like an explosion.

The first fire should be like a good "water smoking" fire in a kiln—a small body of flame, freely burning, with the introduction of a great excess of air. This is merely to heat the air to allow it to drive off the moisture. The flame should be built away from the walls at least 2 ft. All doors should be opened to allow free entrance of air. Continue this fire, being sure to keep the temperature low. Every thousand brick equivalent of plastic contains 3.5 tons of material and the water content of this is close to one-sixth of a ton. It is easily seen then that considerable water is to be evaporated in a furnace where several thousand brick equivalents are used. A brick equivalent is roughly 100 cu.in. In practice it requires 50 to 200 lb. of air per pound of water to be removed from the plastic. It is evident that no general rule can be given for the duration of this smoking period. The amount of water can be estimated not to exceed 20 per cent of the weight of plastic in the furnace. The amount of plastic is known directly from the construction requirements or can be estimated beforehand if advance directions must be given for firing. The amount of air entering the furnace may be calculated roughly when the terminal conditions are known, openings, stack height, etc.

Control of Water Smoking Period

Control of the water smoking period should be such that the temperature does not exceed 250 deg. F. at the wall surface, for the reason that at or below this temperature no great chemical or physical change occurs. The moisture must be removed before reactions start if a wall of close texture is to be had.

After the water smoking period the fire should be built up rapidly. When increasing the temperature, start slowly at first until the body gets to a red heat; then fire more rapidly until the furnace is up to the

working temperature. Here experience will be the best guide, since the rate at which the temperature is raised will depend upon the conductivity of the mass. It must be remembered that if the temperature is raised too rapidly, disruption will occur from the expansive forces by virtue of the temperature differential. The safe temperature gradient is about one-half the modulus of rupture of the dry plastic. The modulus of rupture will vary from 50 to 500 and for the best plastics will be about 250. The safe temperature gradient is then about 25 to 250 deg. per inch. The temperature gradient through a maturing wall is not a straight line, and this must be considered in setting the rate of allowable temperature rise. The writer hesitates to give data on the various firing periods as they vary too much for different materials and furnace conditions. Experience is the best teacher. In the case of an important first installation, it is well to be guided by the manufacturer or an engineer who knows what must be done. As a rule a thoroughly trained engineer can sense the conditions on a visual examination.

Having brought the fire up to the working temperature, carry it at this temperature for a sufficient period to bring the walls to their correct temperature gradient. This often takes many hours, 24 to 60 in average cases. After that period the furnace may be allowed to drop in temperature. A drop in temperature, while raising the temperature to the working value, should be avoided, as this arrests some reactions and may damage the wall. These directions may seem complicated and unnecessary, but experience has shown that under the conditions enumerated good solid walls of long life result. In the majority of failures it will be found that poor firing conditions are responsible.

Rules for Cooling

The following notes on cooling furnaces may seem radical, as they do not follow the usual practice in boiler plants. After getting ready to remove a boiler from the line, open the doors and cool the furnace rapidly until the walls are at a red heat or a little hotter than this. Then close every door. Keep the grates covered and the ashpit closed. From a red heat down, have the temperature drop as slowly as possible. Here are the reasons underlying these directions: When clay products are cooled slowly above 1,700 deg. F., a crystalline structure tends to form. Such structures cause a physical change in volume of the product. To keep the plastic vitreous and avoid this crystal formation, it is desirable to drop the temperature rapidly at first to avoid the formation, then slowly to avoid low temperature reactions that also tend to spall the lining. If these directions are followed, no difficulty will be found from spalling with any good plastic or firebrick. However, attention should be called to the fact that harm will result if an attempt is made to force this initial cooling with water. Several experiences along this line have convinced the writer that this caution is necessary.

Characteristics of Plastic Refractories

For those who are interested in the investigation of various plastic materials, the following notes will be found useful. Laboratory tests of these materials were made by Geller and Pendergast and recorded in the July, 1925, Journal of the American Ceramic Society. The writer's only objection to these tests is the limited number of samples tested. Only twelve tests were made, some on excellent materials and others on poor materials. The writer's laboratory has tested 70 materials, and while results were somewhat similar, many important features were found that are not brought out in the paper mentioned.

In the writer's tests the water content of the wet plastic varied from 9 to 20 per cent. The effect of this water content is to increase the drying or water-smoking time in firing almost directly with the increase of water. The water content giving the best results was 15 per cent. The actual water content depends of course on the amount of plastic clay introduced. Most of the plastics had too little clay, probably done in most cases to decrease shrinkage under poor firing conditions. It is also a factor in some plastics using sagger grog, the plastic clay being kept at a minimum to retain a higher softening temperature. The average plastic firebrick material can be improved by the use of highly plastic fluxfree clays, better mining methods and by the use of only flint brick culls or calcined flint clays as grog.

Drying Shrinkage Unimportant

With plastic refractories the drying shrinkage appears to be an unimportant factor. In the Simulative Service tests of the Navy Department and in the writer's tests, materials of both high and low factors failed to pass. Excessive shrinkage should be avoided. However, a low drying shrinkage is no indication of a good material.

Firing shrinkage is an exceedingly variable factor. Many of the plastics contained ganister (silica rock) which on heating expands, thus counteracting the effect of the clay shrinkage. The firing shrinkage of various materials varied from less than 1 per cent to as much as 20. The use of high alumina clays creates considerable shrinkage, as in the case of Diaspore, Halloysite, Bauxite, etc. Unless such materials are dead burned, their use in plastics is not warranted by either their behavior or their cost. The use of ganister to counteract this effect results in a poor product, since the combination of the two under heat is not under control and many products may be formed, some of which have exceedingly low softening points and a low resistance to slag formations. Ganister tends to produce a crystalline structure subject to spalling.

Modulus of Rupture

Of the dried product the modulus of rupture is of importance only in the case of reinforced arch construction, as discussed previously in this article. In the materials tested by Geller and Pendergast the values were 33 to 111, with an average of 48.6. Of the brands tested by the Navy, the values were 33 to 57. Such materials are satisfactory for wall construction, but not for arch work. In the writer's tests of materials in actual arch construction no material of less than 150 was able to serve. Values of 250 to 500 are more to be desired. This refers to the modulus at room temperature. As a comparison with other refractories, the modulus of rupture of a stiff-mud firebrick, as it comes from the dry tunnel, is from 300 to 550. One trouble the writer has had with plastic refractories is to get sufficient strength in them to make suitable arches. As a rule burned shapes have been used, but in some industrial furnaces the complicated shapes desired were more easily secured from plastics, where suitable materials could be found. It was this necessity that led to the tests and experiments related.

When considered along with the water content, the screen analysis will show some interesting facts. To

show properly the effect of the plastic clay, it is necessary to know its relative plasticity as well as the volume of clay used. Manufactured plastics contain from 30 to 50 per cent fireclay. The use of a very plastic clay in as little amount as needed to insure the proper strength is the correct procedure. Many of the products tested were made with such clays that the fluxing content lowered the softening point so much that insufficient plastic was introduced to give a proper strength value. While the screen test is an easy means to approximate the amount of plastic used, it is unreliable for exact determinations, consequently care should be exercised in its use. For that reason no screen analysis data are given herein. When a suitable standard of plasticity is established, there will be some hope for laboratory tests as an indication of probable performance in practice.

Testing the Material

Chemical composition as determined by the usual analytical laboratory methods was found of little use in determining the probable behavior of plastic firebrick. Combined with a petrographic examination and a great deal of data better results were accomplished. Clark's "Data of Geochemistry" was of much service in this connection. The variables were so numerous, however, that the best results were obtained from practical installation tests. For that reason no material was rejected on a laboratory test alone, except when the tests showed exceedingly poor results.

When properly installed and fired, nearly every plastic refractory showed equal results in spalling resistance. Those failing were to a large extent composed of an excess of ganister. Those showing the best results were composed of select fireclay and flint bats.

Any of the materials having a fusion test of over cone 31 were satisfactory for walls of hand-fired boilers not in excess of 5 ft. high. For forced-draft installations and where walls were high, a fusion test of cone 32-33 was found necessary. All materials of a high fusion point did not stand up, since some were too lean in plastic in an effort to boost the fusion point.

Few of the special compositions with silicate and other binders rendering the product air-setting were found to be satisfactory. The greatest difficulty was the tendency of the binder to melt and close the pores before the interior reactions were completed, resulting in a "bloated" and porous wall.

Cost Considerations

One thousand of the finest flint brick cost about $40, while a cheaper brick equivalent in refractoriness to the plastic firebrick materials can be purchased for $30 to $35 a thousand. About 3.5 tons of plastic are equivalent to 1,000 brick. Plastics sell at from $24 to $120 a ton. There is a labor item on brick approximately 50 to 75 per cent greater than in installing plastic materials. It is easily seen that only the plastic selling at from $24 to $40 a ton can compete with brick, even considering labor cost, if equal life is assumed. With good brick jobs, therefore, plastic cannot hope to compete.

In many of the smaller plants it is quite difficult, however, to obtain a bricklayer with sufficient intelligence to install brick properly. In such cases the plastic with its greater ease of installation has won a place. With due care in firing the initial installation and with care in cooling down, the plastic job can be made to exceed the life of a poorly laid brick job four to six times. It is in such cases that the plastic material shows its merit. Where brick are properly laid, however, there is no difference in life between the two. Often a firebrick job, when properly made, will exceed the life of any plastic job on account of the better burning of the ceramic material. That brick are better burned is evident, because they are immersed completely in flame in the kiln, whereas with the plastic only one side is fired to a maturing heat all through.

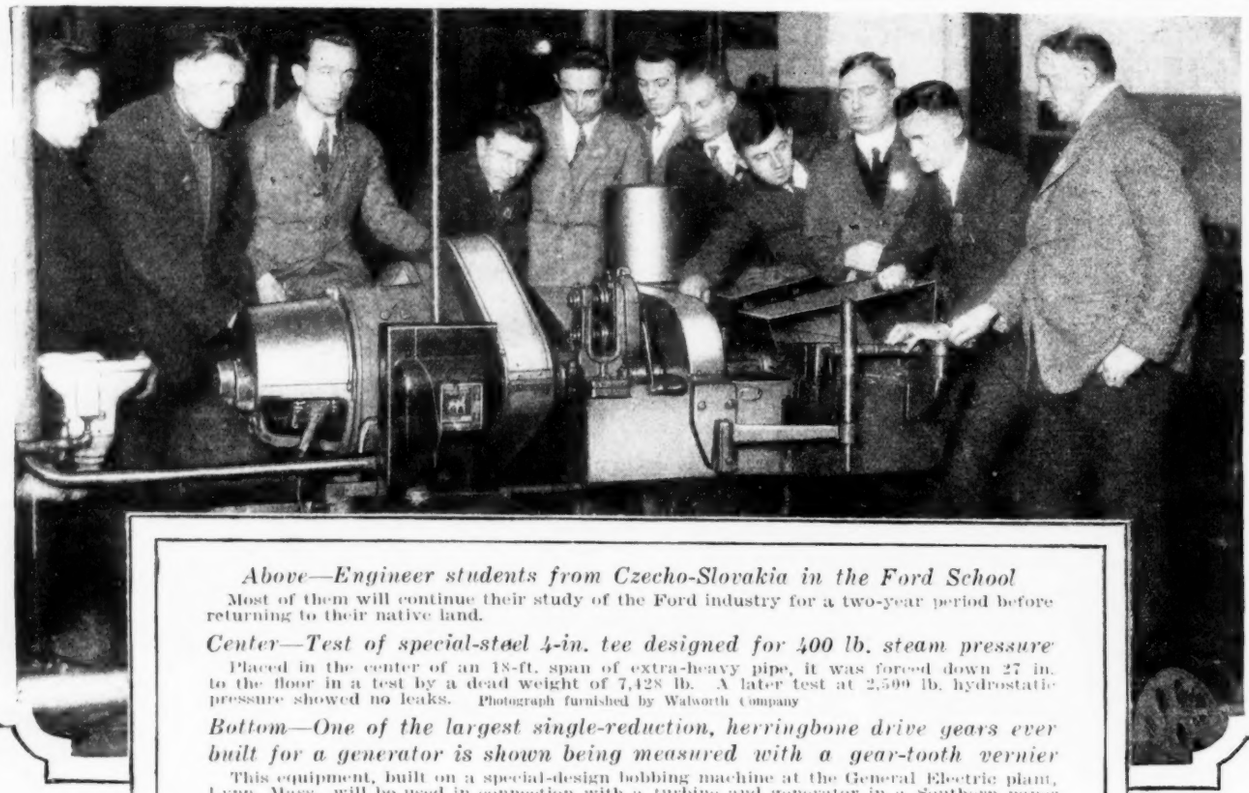
For complicated furnace structures and for rapid construction at little cost with any available labor, the plastic plays an economical part. Plastic refractories are also of greater use than firebrick in repairs and minor construction. For that use it has the greatest field.

Reasons for the high prices of plastic materials are the demands from many plants that the manufacturer give them large trial lots and that he carry the material in convenient warehouses where the user may obtain it on a moment's notice. Free service of other kinds tends to increase the price. Very few if any of these items are legitimate expenditures for the manufacturer. When the user learns that he can just as well carry a goodly sized stock of material, so that the manufacturer can reduce his warehousing expense and his sales effort, then the price of the plastic material will come down to a level that will allow it to compete with firebrick in any case aside from extremely severe service. The cheaper plastic materials mentioned in the foregoing prices were quoted by manufacturers who do not maintain a sales force, warehouses and other expensive distribution accessories.

There seems to be little reason for not lubricating elevator cables when the advantages are weighed against the objections. About the most serious objection is the extra work and the care that must be exercised to prevent the lubricant dropping into the car. A good non-acid, medium-heavy oil that will penetrate to the core and also stick to the surface is desirable. There is not much value in a lubricant that is so thin that it will run easily and drip from the rope. On the other hand, it should not be so thick and sticky that it will not penetrate into the hemp center. A number of elevator manufacturers and oil companies have for sale lubricants that they recommend for this purpose. Experiments have proved that a non-acid lubricant having a Saybolt viscosity of from 1,000 to 2,000 sec. at 210 deg. is well suited for this purpose.

A study of soot removal and prevention compounds is being made by the Bureau of Mines, Department of Commerce. In order to determine the effectiveness of such compounds for their stated purposes, a study is being made of the flue-gas temperatures and gas composition necessary for the reactions to take place both with and without the use of the compounds or other materials. The investigation will be extended to a study of the effectiveness of the compounds under conditions similar to those to which they are supposed to be applied.

All deposits found in air-compressor cylinders are not due to carbonization of the oil. Many deposits, when analyzed, show a large percentage of dust drawn in from the atmosphere and all kinds of metallic substances that could never be secured in any other way. A little oil will bind these materials together in a solid mass, which is just as effective as a carbon deposit so far as interfering with the compressor operation.



Above—Engineer students from Czecho-Slovakia in the Ford School

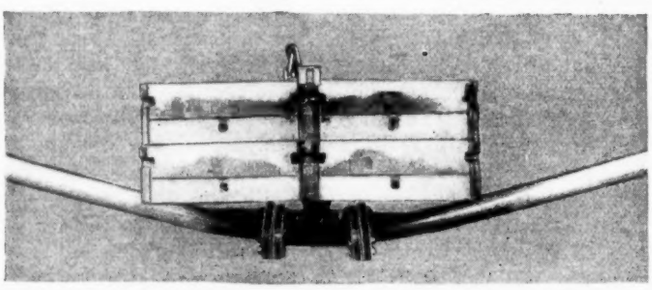
Most of them will continue their study of the Ford industry for a two-year period before returning to their native land.

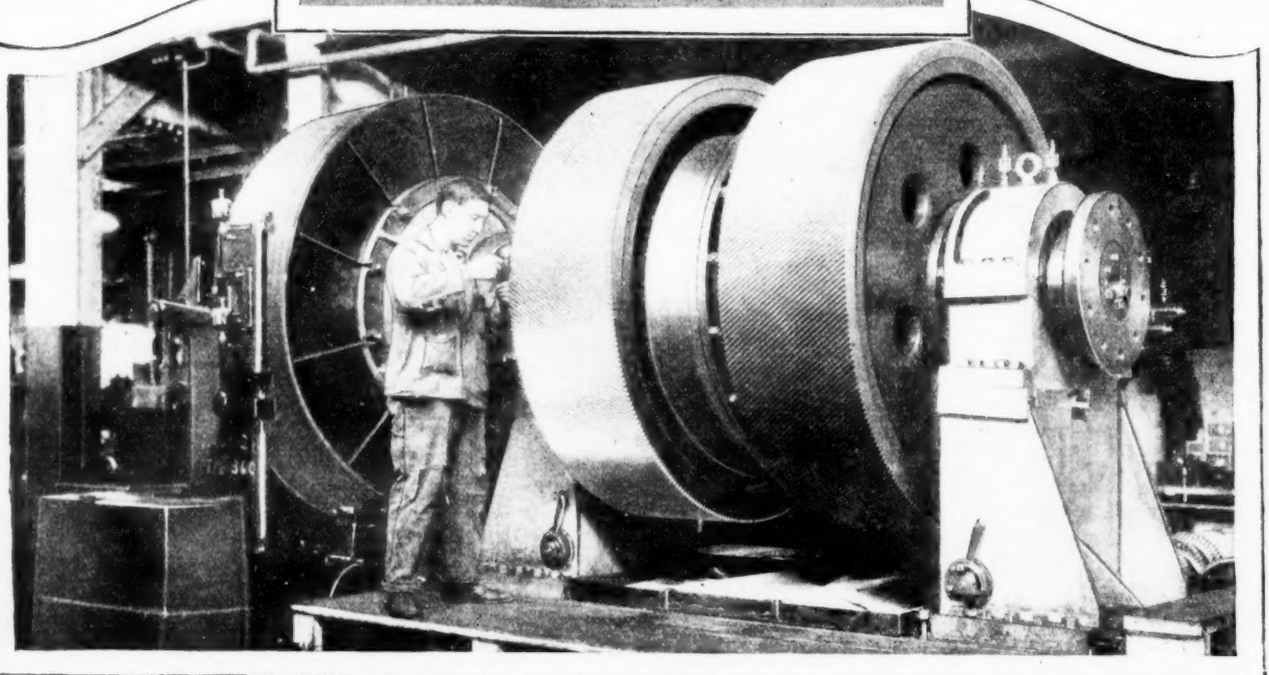
Center—Test of special-steel 4-in. tee designed for 400 lb. steam pressure

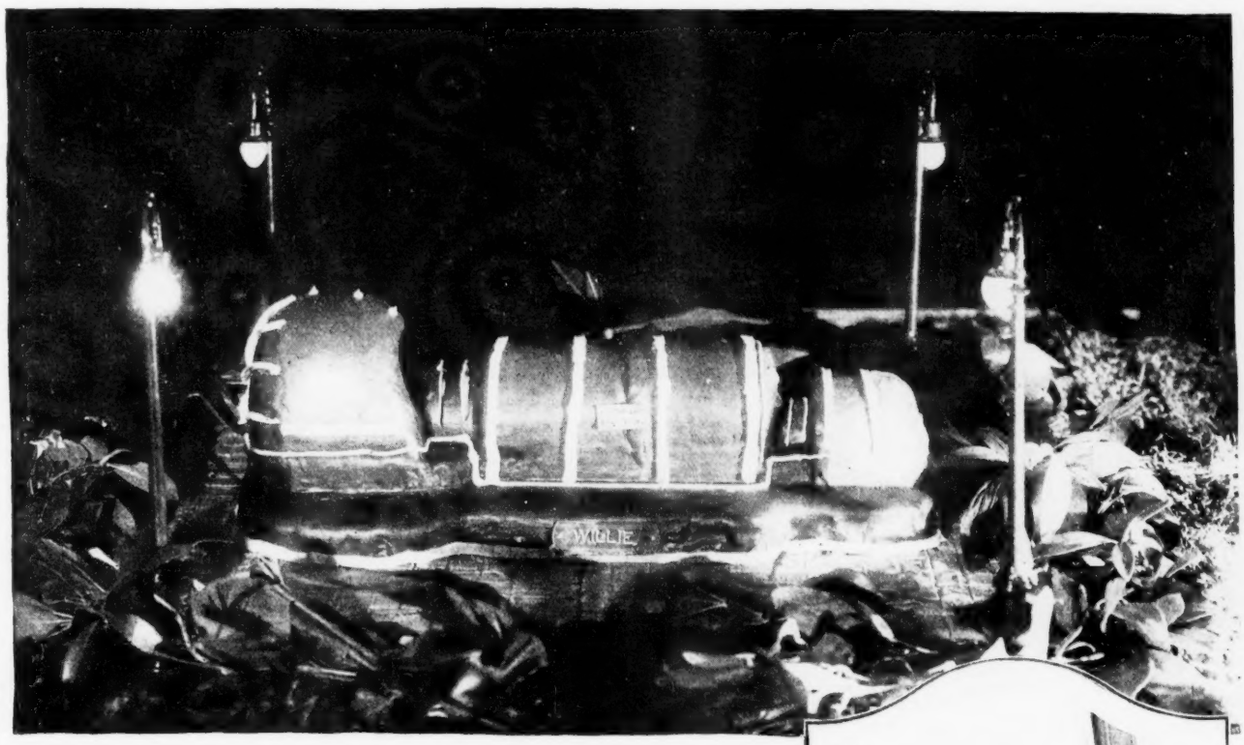
Placed in the center of an 18-ft. span of extra-heavy pipe, it was forced down 27 in. to the floor in a test by a dead weight of 7,428 lb. A later test at 2,500 lb. hydrostatic pressure showed no leaks. Photograph furnished by Walworth Company

Bottom—One of the largest single-reduction, herringbone drive gears ever built for a generator is shown being measured with a gear-tooth vernier

This equipment, built on a special-design hobbing machine at the General Electric plant, Lynn, Mass., will be used in connection with a turbine and generator in a Southern paper mill.







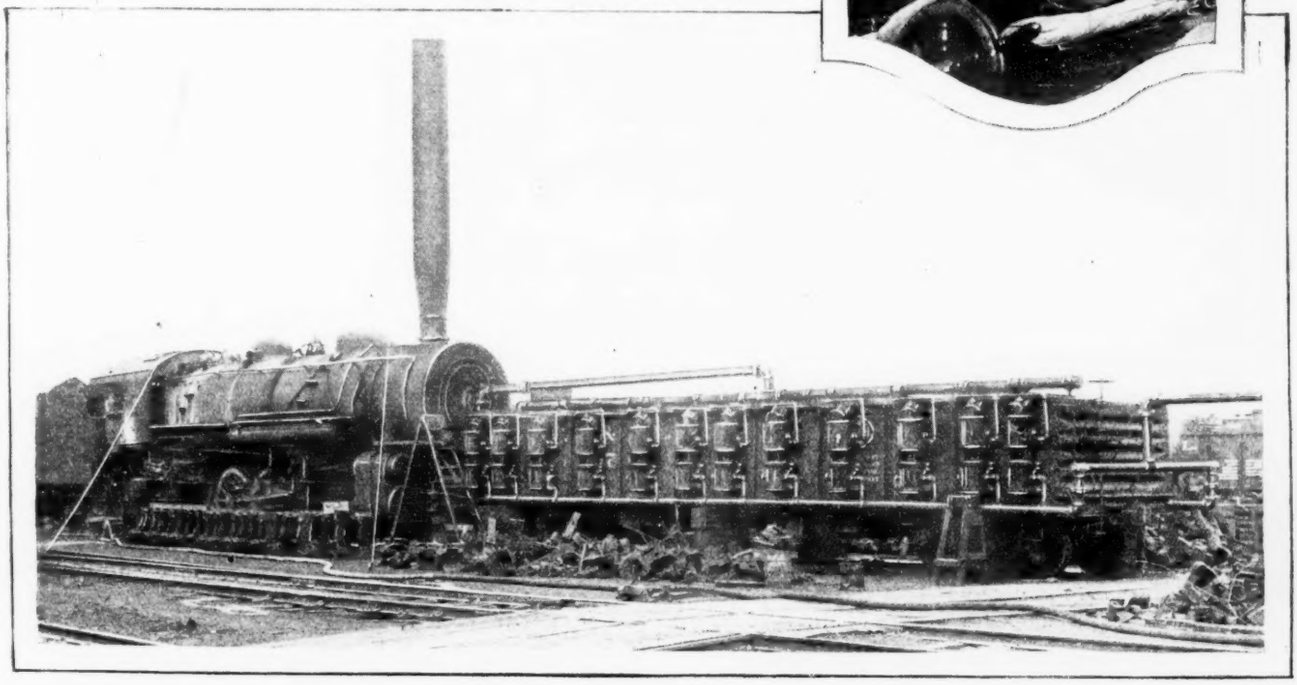
Above—This turbine was eaten

At a Christmas party in honor of President C. L. Edgar, of the Edison Electric Illuminating Company of Boston, and given by department heads of the operating bureau, a feature was a model of the new Edgar Station containing, in the shape of a birthday cake, a replica of a 30,000-kw. unit.

Right—David Moffat Myers, consulting engineer, reverts to wind power. At least he seems contented with the "water rate" of "Flying Cloud" on her cruise from Providence to New York

Below—Emergency compressor plant keeps shop running

Recently, the air-compressor plant broke down at the Beach Grove shops of the Big Four Railroad, near Indianapolis. A locomotive was backed upon a siding and equipped with a temporary stack extension to furnish steam for a battery of locomotive air compressors clamped to the side of an idle car. This outfit kept the plant going until the emergency was over.



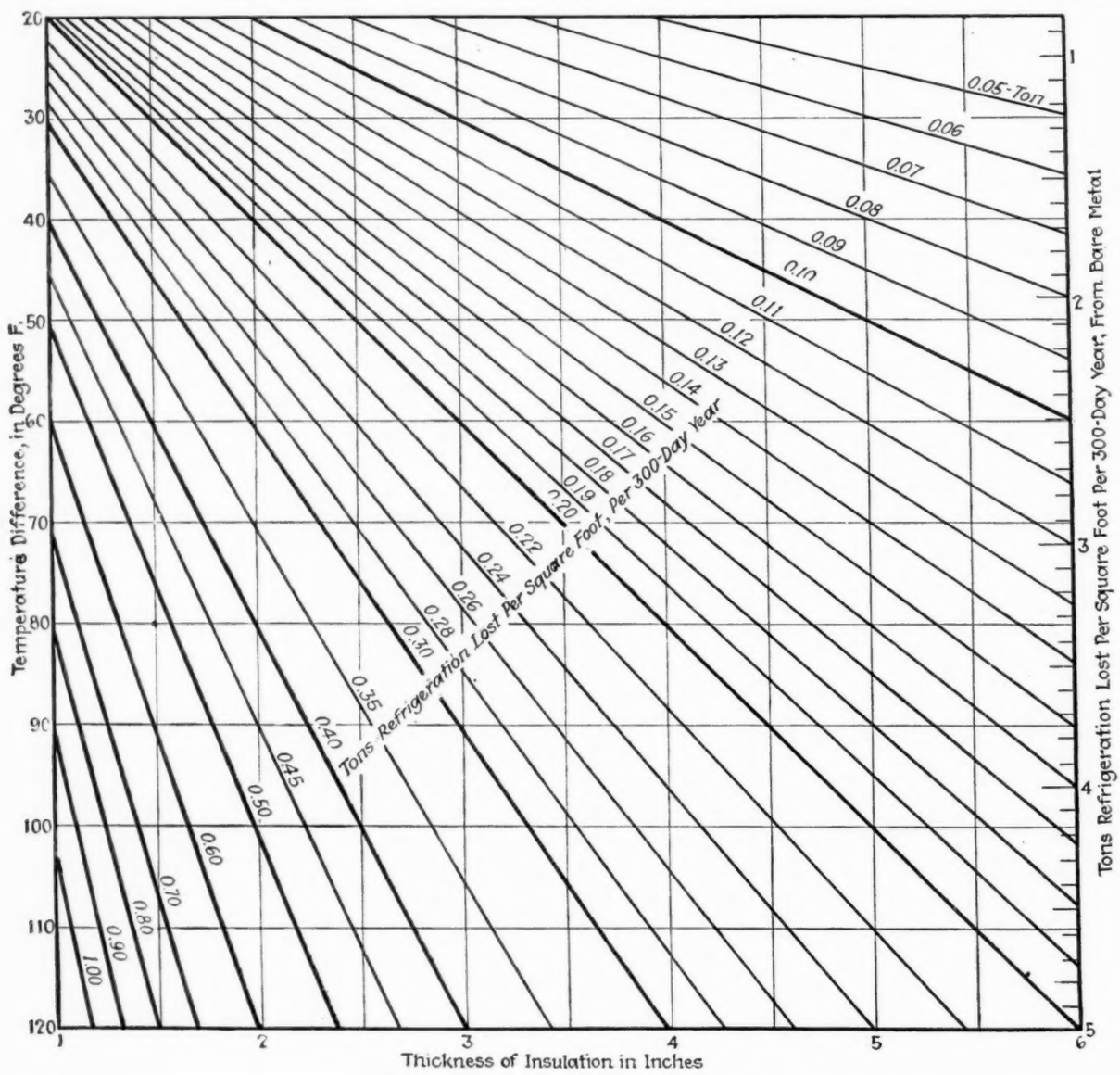
Heat Leakage in the Refrigerating Plant

Chart Showing Leakage from Bare and Insulated Tanks—Permits Calculation for the Most Efficient Thickness of Covering

By W. S. HUNTINGTON

INDUSTRIAL processes in which refrigeration is required usually involve the use of one or more tanks or liquid containers, their contents being cooled by vaporizing coils. In most plants such tanks are situated in rooms in which the temperature of the air is much higher than that at which the liquid is held, hence unless the tank surface be insulated, considerable heat leaks through the metal wall of the container. Even if it be insulated, there is necessarily a certain amount of heat conduction through the cork or other covering material.

Knowing the nominal conductivity of the covering, its thickness and the difference in temperature between the tank contents and the outside air, it is a simple matter to compute the probable heat leakage in B.t.u. per hour or day and thus determine what refrigerating effort is being wasted in needless cooling of the air of the room.



Heat loss through insulation of tanks

The chart is offered as a time-saver for calculations of this sort. It is based on a heat leakage of 9.6 B.t.u. per sq.ft. per 24-hour day through one inch thickness of insulation, per degree of difference between internal

and external temperatures. Tests of good coverings may show this to be somewhat excessive, but it is well to allow a value ample to take care of possible minor defects, such as open joints in lagging, presence of moisture, broken coverings, etc. Conductivity is in inverse proportion to thickness of material; for example, for 2-in. covering it would be 4.8 B.t.u. per sq.ft. per day per degree, and for 3-in. it would be 3.2 B.t.u.

How to Use the Charts

Cooling effort usually is measured in tons of refrigeration, 288,000 B.t.u. of heat carried out by the refrigerant being rated as a ton of refrigeration. The capacity of the plant usually is known, also the operating cost per ton, consequently it is convenient to compute the cost of the wasted effort in terms of tons of refrigeration. The chart is constructed for a 300-day year; values for any other time period are proportional. The loss in tons of refrigeration, per square foot of insulated surface, per degree of temperature difference and for any usual thickness of insulation, is readily found.

For example, if the temperature difference be 50 deg. F., and the thickness of insulation 2½ in., the loss per year is seen to be 0.20 ton of refrigeration per square foot, and this multiplied by the number of square feet and by the cost per ton gives the cost of the waste in dollars per year. Thus the chart makes possible a quick comparison between the probable losses through different thicknesses of proposed or existing coverings for the purpose of determining the justifiable cost of an insulation. In the example given, if the surface to be covered be 80 sq.ft. and the cost of refrigeration per ton, 70c., heat leakage through a 2½-in. insulation would cost $80 \times 0.70 \times 0.20 = \$11.20$ per 300-day year, or at the rate of $1.12 per month. If the thickness were made 4 in. instead of 2½, the loss per square foot would be only 0.124 ton and the yearly cost $6.94.

Leakage with Bare Pipe

The scale at the right of the chart shows the heat leakage through the bare metal of tanks or pipes, assuming that the conductivity is 40 B.t.u. per sq.ft. per 24 hours per deg. difference between temperatures on the inside and the outside of the tank or pipe. The loss per year for a 50-deg. temperature difference is seen to be 2.07 tons of refrigeration, which at the rate given would cost $80 \times 0.70 \times 2.07 = \$115.92$, hence the saving per year effected by use of a 2½-in. insulation is $\$115.92 - \$11.20 = \$104.72$, or for 4-in. insulation, $108.98.

The chart will serve for pipe covering as well as for tank lagging, the surface exposure of a pipe to be taken as the mean between the surface of the pipe metal and the exterior surface of the pipe covering.

Center distance has an appreciable effect on the transmission capacity of a belt on a horizontal or angle drive, because of the weight of belt material suspended from pulley to pulley. A long-center-distance drive, when operating under load, will have more tension on its slack side than a short center drive. Other things being equal, the tension on the slack side of a belt under load is a measure of its capacity, and therefore a long center drive inherently has more capacity than a short one.—*Leather Belting Exchange Foundation.*

Tests with Boiler Oil in a Hesselman Airless-Injection Engine

By Edwin Lundgren*

In instances of competition between oil engines and steam power, advocates of the latter often point to the great advantage of steam plants that they are able to burn satisfactorily cheap fuel oil which cannot be utilized in oil engines and that therefore even the oil-fired steam plant may be more economical, although under the boilers admittedly two to three times as much oil per horsepower-hour is consumed as in Diesel engines. While this question is debatable and introduces a good many other points to be considered, it nevertheless touches a point that deserves attention. Conditions must be improved so that cheaper oil may be used in oil engines, and when this is done the burning of oil under boilers will be more generally recognized as waste.

It is true in some cases Diesel engines have been successfully operated on heavier grades of oil, but as a rule both makers and users of such engines specify a lighter oil having a specific gravity of not more than 0.91. The semi-Diesel engine cannot be operated on boiler oil, and many solid-injection engines have met with difficulties when trying to use this grade of fuel.

Some tests, recently carried out with heavy Mexican boiler oil in a Hesselman airless-injection engine under the supervision of Prof. E. Hubendick, of the Royal University of Technology of Stockholm, indicates that a properly designed solid-injection engine will handle the heaviest of oils.

Oil Used on Test

The fuel used had a specific gravity of 0.954 at a temperature of 68 deg. F., and its Saybolt viscosity was 325 at 76 deg. F. and 85 seconds at 212 deg. F.

The fractional distillation yield up to 480 deg. F. was 5 per cent, from 480 to 570, 12 per cent, from 370 to 660 deg. F., 12 per cent, and from 660 to 680, 51 per cent, leaving a residue of 20 per cent, which, when cooled down, consisted of a solid brittle mass. According to these results the oil evidently was a residual oil from which the more volatile parts, as gasoline and kerosene, had been extracted, being in fact a typical boiler oil. It contained 2.52 per cent sulphur and 10.6 per cent asphalt insoluble in alcohol ether and 7.1 per cent asphalt insoluble in standard benzine with a specific gravity of 0.7. Its net calorific value was found to be 17,300 B.t.u. per lb.

In order to be able to use an oil having such a high viscosity, it is necessary to heat it, because otherwise it would hardly be possible for the fuel pump to force it through the piping. This heating means a certain inconvenience, but the heating needs only to be very moderate, a temperature of 140 deg. F. making the oil sufficiently fluid. During normal service the discharged cooling water may be utilized for this purpose, as may also the exhaust if necessary. The possible saving in the fuel bill, which in many localities may amount to fully 30 per cent, would even in comparatively small plants certainly justify the inconvenience of the heating arrangements.

During the tests the engine was started on ordinary

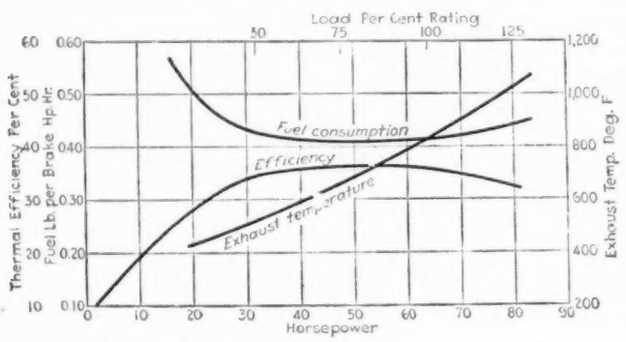
*Consulting engineer, Stockholm, Sweden.

Diesel, or solar, oil and the discharged cooling water, the temperature of which during the tests was kept at 150 to 160 deg. F., was used to heat the oil. When this had become sufficiently fluid, the fuel line to the engine pump was connected to the boiler-oil reservoir.

The engine used for the tests was originally an ordinary four-stroke-cycle, two-cylinder Diesel engine developing 65 b.hp. at 300 r.p.m., but had been rebuilt and equipped with the Hesselman airless-injection system, thus dispensing with the air compressor, but fitted with new cylinder covers, pistons, fuel pump and automatic fuel valves. The cylinder diameter of the engine was 9.85 in. and the stroke 14.47 in.

Test Procedure

The test was prepared very carefully and all necessary precautions were taken to obtain correct readings. The power delivered was measured by means of a Heenan & Froude hydraulic dynamometer, which had been carefully checked. The fuel consumed during each test was determined by weighing. The revolutions were counted by a revolution counter connected to the engine during the entire test. Besides, there was a tachometer arranged so one could determine the speed at any moment and observe any speed variations. The temperatures of the exhaust, the cooling water and the



Results of test of Hesselman engine using boiler oil

fuel were recorded, and also indicator cards were taken at different loads.

The tests comprised fuel-consumption tests at different loads, varying from nearly no load to approximately 30 per cent overload, a 24-hour non-stop run and finally two shorter runs on solar oil to insure that at the end of the tests the same conditions prevailed in the engine as at the start.

Engine Behavior

During all these tests the engine performed satisfactorily, without the slightest trouble or difficulty. The combustion was excellent and the exhaust clear, except at very light load and also at 25 per cent overload, at which times the exhaust became smoky.

The fuel consumption was low; at full load it amounted to 0.415 lb. per brake horsepower-hour.

When running on the richer solar oil, the fuel consumption was of course less, but it was quite interesting to note when computing the number of heat units consumed per brake horsepower-hour, that this figure was almost the same when operating on the heavy boiler oil as when running on ordinary Diesel oil, namely, approximately 7,100 B.t.u. per brake horsepower-hour, corresponding to a total efficiency of close to 36 per cent.

The governing of the engine left nothing to be desired. At 25 per cent overload the speed was 306 r.p.m., and when the engine was running idle the speed was 309.5 r.p.m. During the 24-hour test a uniform load was maintained and the running of the engine was steady and regular. The governor, the position of which could be observed on a dial, remained practically stationary during the entire time, the tachometer showing a slow variation between 302 and 304 r.p.m.

The governing is not accomplished by varying the beginning of the fuel injection, as is usual in the ordinary Diesel engine, but the governor controls the end of the fuel delivery by influencing the opening of the suction valve. The beginning of the delivery, or the injection, remains the same at all loads, although it may be adjusted by hand while the engine is running.

After the end of the tests, a careful inspection of the interior of the engine was made and everything was found to be in good condition. Only a very light soot deposit could be observed on the exhaust valves and pistons. The holes in the injection nozzle were perfectly clean and unobstructed. No part of the pistons showed any sign of having been overheated, although the engine had been subjected to a heavy overload.

High Overload Capacity

An overload of 25 per cent called for a brake mean effective pressure of 95 lb. per sq.in. At the rated load of 65 b.hp. the brake mean effective pressure is approximately 75 lb., a fairly high figure for Diesel engines. Inasmuch as a higher m.e.p. can be safely maintained for any length of time, the builders would be justified in increasing the rating. In fact, when designing new engines, it has been shown that a brake m.e.p. of 82 lb. per sq.in. is a reasonable figure which can be allowed and guaranteed as a basis for the rating. It is to be observed that the high m.e.p. are obtained without necessarily involving excessive maximum pressures. During the tests with the boiler oil the highest pressure obtained at 25 per cent overload amounted to 620 lb. per sq.in., the compression pressure being 400 lb.

It deserves to be pointed out that it must be the aim of any engine designed, to obtain as high a mean effective pressure as possible while at the same time retaining moderate maximum pressures. This has been one of the main difficulties with which solid-injection engines have had to contend, and as far as the author knows, hardly any other engine can in this respect show as good results as the engine under discussion. In several cases where otherwise good results and almost as low a fuel consumption had been attained, a closer investigation revealed that the maximum pressures had been exceedingly high. High pressures would, of couse, be prohibitive in a good standard design, as they are likely to overstrain the engine.

Another good feature which the engine showed during the test was that it was not necessary to make any adjustments when changing from one fuel to another or when varying the load.

A recently accepted British Patent Specification (No. 237,604) of the British Thomson-Houston Co., Ltd., deals with a turbine designed for pressures exceeding 1,000 lb. per sq.in. It is a multi-stage impulse machine with stepped rotor. The turbine has no bearing at the high-pressure end, the entire rotor being overhung from the low-pressure-end bearing. This type avoids the necessity of packing against high-pressure steam.

Effects of Changing the Load on a Synchronous Motor

By J. M. CUNNINGHAM
Power Engineering Department, Westinghouse Electric & Manufacturing Company

THE question has often been asked, What is the effect on the power factor of a power system when the load on a synchronous motor is varied? At what load on the motor will the corrective effect on the system's power factor be the greatest? In this article the author discusses these questions.

THE effect on the power factor of the system due to varying the load of a synchronous motor, depends on several conditions: The power factor of the system, the system kva. load, the power-factor rating of the motor, the kva. rating of the motor, the design proportions of the motor and its relative kva. compared to the system kilovolt-amperes.

There are certain assumptions to be made to have a basis for analyzing the effects of varying the load of a synchronous motor on the system power factor. It will be assumed, then, that the system's power factor is initially lagging without the motor on the system, that the motor is operated at unity or some leading

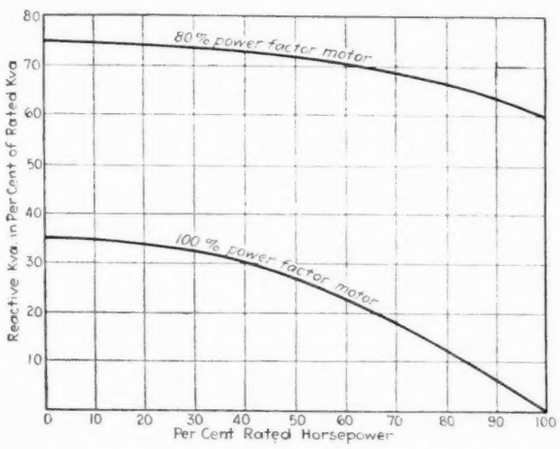


Fig. 1—With constant field current the leading reactive kva. increases as the mechanical load is reduced on a synchronous motor

power factor to supply reactive leading kva., in order to raise the system power factor, with other conditions of the system remaining constant, and that the motor excitation remains constant at the value of field current necessary to deliver full-load output at the rated power factor.

First, consider the effect on the motor of changing its load while maintaining its excitation constant. Standard synchronous motors are designed to operate at unity or 80 per cent leading power factor, and only these two types will be considered. The amount of reactive kva. that a synchronous motor will carry depends upon its load, the power factor at which it operates, its design proportions and rating.

At full mechanical load on the motor its reactive kva. is a minimum, the total kva. is a maximum and the

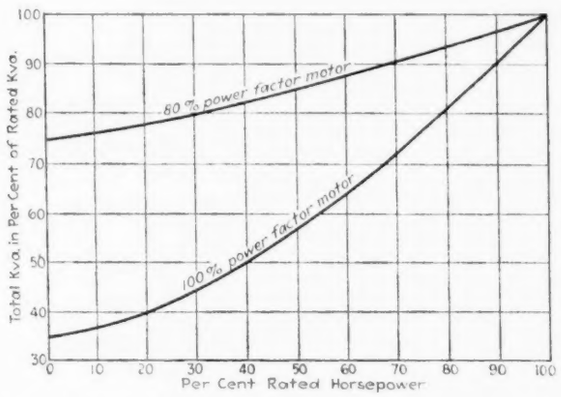


Fig. 2—Curves show how the total kva. decreases as the load is reduced on a synchronous motor with constant field excitation

maximum rated power factor is obtained. As the mechanical load decreases, the reactive kva. increases and the total kva. and power factor decreases in the leading direction. At zero mechanical load the reactive kva. is a maximum, the total kva. is a minimum and the power factor is approximately zero per cent leading. For a typical standard design of a unity (100 per cent) power factor motor, the reactive kva. in percentage of full-load kva. varies from zero per cent at full mechanical load, Fig. 1, to 35 per cent at no load.[1] The power factor decreases from 100 per cent at full load to approximately zero per cent leading at no load, as indicated in Fig. 3.

Unity Power Factor Motors

Similarly, for a typical standard design of 80 per cent power factor motor, as the load decreases the reactive kva., in percentage of full load, varies from 60 per cent at full load to 75 per cent at no load, as shown in Fig. 1. The total kva. decreases from 100 per cent at full load to 75 per cent at no load, Fig. 2. The power factor decreases from 80 per cent leading at full load to zero per cent leading at no load, Fig. 3.

From the data, Figs. 1 to 3, vector diagrams may be constructed to show what will be the effect of adding a synchronous motor to the power system. Assume a system load of 1,800 kw. at 71 per cent power factor,

[1]Data of Figs. 1 and 2 are similar to curves used by Quinten Graham's article on synchronous motors appearing in the Feb. 10, 1925, issue of *Power*.

to which is to be added a 500-kva. unity power factor motor. Fig. 4 is a diagram of the system load with the motor connected at full load and at no load. To construct the system-load diagram, lay off to scale on the horizontal line AX, distance AB equal to 1,800 kw. For example, allow 1 in. to represent 100 kw., then the line AB will be 18 in. long. The slope of line AC, which represents the system kva., is obtained from the system power factor, which in this case has been assumed to be 0.71. The power factor is the cosine of the phase angle between the voltage and the current in the system. It also works out to be the angle between the kw. and kva. load of the system. Therefore by referring to the table of sines and cosines, an angle can be found whose cosine corresponds to the power factor. In this case the power factor is 0.71, which will be found in the table to correspond to an angle of about 45 deg., therefore the angle between the line AC representing the system kva. and the line AB representing the system kw. load, is made 45 deg. The system kva. load is equal to kilowatts divided by the power factor, or $1,800 \div 0.71 = 2,535$. Therefore the line AC is made 25.35 in. long. The side BC of the triangle ABC represents the reactive lagging kva. load on the system, which in this case is equal to the kw. load.

At full load a unity-power-factor motor takes a kilowatt load only from the system, therefore this load would be represented by a horizontal extension of line AB. To simplify the diagram, the motor load can be drawn horizontally from C and a distance CD laid off on line CZ representing to scale the full load of the motor. In this diagram the scale was assumed to be 100 kw. per inch, then CD would be made 5 in. long.

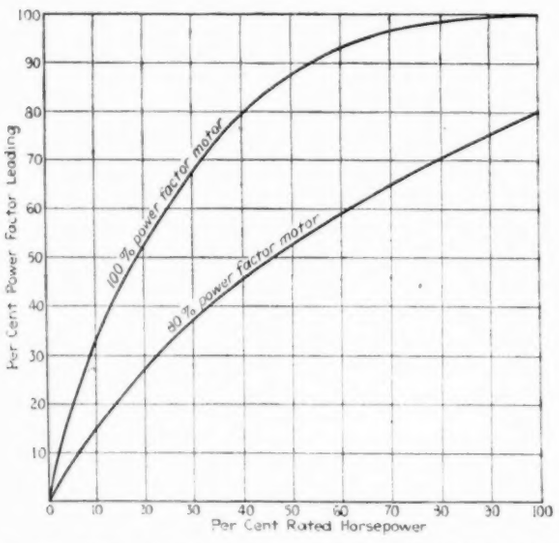


Fig. 3—Power-factor curves for synchronous motors

The line joining A and D represents to scale the total load on the system after the motor is added, and the cosine of the angle between AB and AD is the power factor of the new load. This angle may be calculated, or can be measured by a protractor and the cosine obtained from the table. In either case angle θ will be found to be about 37 deg., the cosine of which is 0.80, and is the power factor of the new load. The kva. load is equal to the kw. load divided by the power factor or in this case $(1,800 + 500) \div 0.80 = 2,875$. Another way of obtaining the different values is to scale off the kva. load on line AD and divide this value into the total kw. load to obtain the power factor, or $2,300 \div 2,875 = 0.80$.

Referring to Fig. 1 it is found that at no load the unity power factor motor takes from the system a load equal to 35 per cent of its rated kva. With the motor in question this would amount to $500 \times 0.35 = 175$ kva. The no-load power factor is practically zero leading.

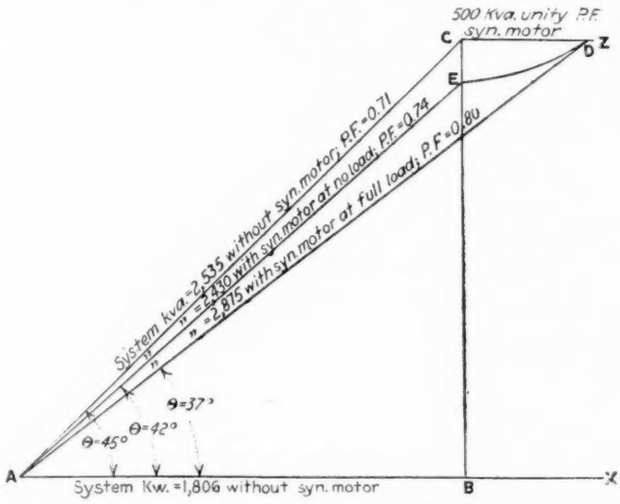


Fig. 4—Diagram showing the effect of adding a unity power factor synchronous motor to a power system

In Fig. 4 the system reactive kva. load, which is lagging, is represented by the line BC in an upward direction. Adding a given amount of leading kva. to the system neutralizes an equal amount of lagging reactive kva. Therefore the motor's kva. at no load will be laid off on BC downward from C a distance CE. The motor's kva. at no load is 175, then as the assumed scale of the diagram is one inch equals 100 kva., CE will be made $1\frac{3}{4}$ in. long. A line joining AE represents the load on the system with the motor operating at no load. The value of the load can be obtained by scaling off line AE, which would be found to be about 24.3 in. long, and would represent $24.3 \times 100 = 2,430$ kva. The power factor is obtained by dividing the kw. load by the kva. load, or $1,800 \div 2,430 = 0.74$, which corresponds to the cosine of an angle of 42 deg. If three or four intermediate points are taken between no load and full load on the motor, it will be found that these points can be joined by a curve such as ED.

Eighty per Cent Power Factor Motors

It will be observed that with the motor operating at no load on the system, the total load has been reduced from 2,535 to 2,430 kva. and the power factor is raised from 0.71 to 0.74. It will also be seen that the maximum power factor correction is obtained with the motor operating at full load and unity power factor, and the minimum correction is obtained with the motor operating at no load and zero power factor leading.

Fig. 5 shows the 80 per cent power factor 500-kva. motor applied to the same load as in Fig. 4. In this case the power factor of the motor is 0.80 leading, therefore the line representing the motor's full-load kva. will not fall along the kw. line CZ, but makes an angle of 37 deg. below this line, as CY. The 37 deg.

is an angle whose cosine is 0.80, the power factor of the motor at full load. On this line distance *CD* is laid off equal to 500 kva. A vertical line drawn from *D* will intersect line *CZ* at a point *F*, making *CF* equal the 400 kw., the power load of the motor. A line drawn from *A* to *D* represents the system load with the motor in operation, which, if scaled off, would be found to be about equal to 2,660 kva. Another way of obtaining the kva. is to measure the angle θ with a protractor,

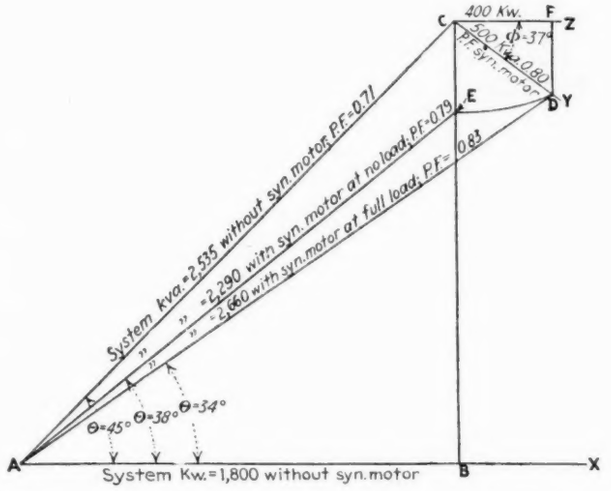


Fig. 5—Diagram showing the effect of adding an 80 per cent power factor motor to a power system

and would be found to equal about 34 deg., the cosine of which is 0.83. The total kw. on the system is 1,800 + 400 = 2,200, and this divided by the power factor gives the kva., or 2,200 ÷ 0.83 = 2,660 approximately. In this case a mechanical load equivalent to 400 kw. has been added to the system, but the total load has been increased only from 2,535 to 2,660 kva., or 125 kva. This has been due to increasing the power factor from 0.71 to 0.83.

At no load it is seen on the curve, Fig. 2, that the motor takes 75 per cent of its rated kva., or in this problem 500 × 0.75 = 375 kva. This load may be assumed to be at zero power factor leading, therefore distance *CE* equal to 375 kva. is laid off on the line *CB*. A line joining *A* and *E* will represent to scale the load on the system, and the cosine of angle θ, 38 deg., equals the power factor, 0.79, of the system. In this case adding the motor to the system reduces the total load from 2,535 to 2,290 kva., or 245 kva. By obtaining intermediate points the curve *ED* can be drawn, which shows that at all loads on the motor, between zero and 100 per cent, the system load will fall between *AE* and *AD*, therefore the maximum power factor correction is obtained with the motor at full load and the minimum at no load. In both Figs. 4 and 5 it has been assumed that the motor's no-load power factor is zero; this, however, is not the case, but so far as the practical results are concerned it is so close to zero that zero power factor may be assumed, and this also simplifies the problem.

Where Greatest Correction Is Obtained

By comparing Figs. 4 and 5, the greatest power-factor correction is found to be with the 80 per cent power factor motor operating at full load and that the minimum corrective effect is produced by the unity power factor motor operating at no load. These relations that have been shown are for one set of conditions only. For example, when the power factor of the system's load is about 91 per cent, the corrective effect of adding the unity power factor will be about the same at all loads. This is on the assumption that the system's kilowatt load without the motor remains at 1,800. When the power factor of the system's load is greater than 0.91 per cent, the motor will have a greater corrective effect at light loads than at full loads. With power factor less than 0.91, full-load operation of the motor gives the greatest correction.

Figs. 4 and 5 also show that at the conditions for which the diagrams were constructed the 80 per cent power factor motor at full load gives the greatest correction in the system. This holds true only down to a system power factor of 0.24, before adding the motor; below this value the unity power factor motor will give the greatest correction at full load. At no load the 80 per cent power factor motor will provide the greatest amount of correction at all system power factors, except at high system power factors, when it may change the power factor to leading. In general the system power factors will be found within the range of 50 to 90 per cent, so that the effects shown in Figs. 4 to 5 will hold true in most cases.

Other Factors that Should be Considered

There are a number of other factors, previously mentioned, that affect the problem of determining the effect on the power factor of a power system, caused by changing the load on a synchronous motor with constant excitation, that have not been considered, but the foregoing discussion is sufficient to show that there is no direct answer to the question. Each case must be worked out individually, since the result depends on several conditions, each of which will modify the effects

NATURAL SINES AND COSINES

Ang.	Sine	Cosine	Ang.	Sine	Cosine	Ang.	Sine	Cosine
0	0.0000	1.0000	31	0.5150	0.8572	62	0.8803	0.4695
1	0.0174	0.9998	32	0.5299	0.8481	63	0.8910	0.4540
2	0.0349	0.9994	33	0.5446	0.8387	64	0.8988	0.4384
3	0.0523	0.9986	34	0.5592	0.8290	65	0.9063	0.4226
4	0.0698	0.9976	35	0.5736	0.8192	66	0.9136	0.4067
5	0.0872	0.9962	36	0.5878	0.8090	67	0.9205	0.3907
6	0.1045	0.9945	37	0.6018	0.7986	68	0.9272	0.3746
7	0.1219	0.9926	38	0.6157	0.7880	69	0.9336	0.3584
8	0.1391	0.9903	39	0.6293	0.7771	70	0.9397	0.3420
9	0.1564	0.9877	40	0.6428	0.7660	71	0.9455	0.3256
10	0.1737	0.9848	41	0.6561	0.7547	72	0.9511	0.3090
11	0.1908	0.9816	42	0.6691	0.7431	73	0.9563	0.2924
12	0.2079	0.9782	43	0.6820	0.7314	74	0.9613	0.2756
13	0.2250	0.9744	44	0.6947	0.7193	75	0.9659	0.2588
14	0.2419	0.9703	45	0.7071	0.7071	76	0.9703	0.2419
15	0.2588	0.9659	46	0.7193	0.6947	77	0.9744	0.2250
16	0.2756	0.9613	47	0.7314	0.6820	78	0.9782	0.2079
17	0.2924	0.9563	48	0.7431	0.6691	79	0.9816	0.1908
18	0.3090	0.9511	49	0.7547	0.6561	80	0.9848	0.1737
19	0.3256	0.9456	50	0.7660	0.6428	81	0.9877	0.1564
20	0.3420	0.9397	51	0.7771	0.6293	82	0.9903	0.1392
21	0.3584	0.9336	52	0.7880	0.6157	83	0.9926	0.1219
22	0.3746	0.9272	53	0.7986	0.6018	84	0.9945	0.1045
23	0.3907	0.9205	54	0.8090	0.5878	85	0.9962	0.0872
24	0.4067	0.9136	55	0.8192	0.5736	86	0.9976	0.0698
25	0.4226	0.9063	56	0.8290	0.5592	87	0.9986	0.0523
26	0.4384	0.8988	57	0.8387	0.5446	88	0.9994	0.0349
27	0.4540	0.8910	58	0.8481	0.5299	89	0.9998	0.0174
28	0.4695	0.8830	59	0.8572	0.5150	90	1.0000	0.0000
29	0.4848	0.8746	60	0.8660	0.5000			
30	0.5000	0.8660	61	0.8746	0.4848			

produced by the other. As has been shown in Figs. 4 and 5, the greatest corrective effect on the system power factor is not necessarily obtained with the motor operating at no load as a synchronous condenser on the system. On the average power system the greatest corrective effect will be obtained with the motor operating at full load.

Changes in the power factor of a power system produced by changing the load on a synchronous motor are generally a minimum, when the power factor of the system is high. In this case the greatest corrective effect is obtained between one-half and no load on the motor. When the power factor of the system is low, the greatest corrective effect will be obtained at between one-half and full load on the motor.

The kva. load on the system affects the changes in system power factor, produced by changing the load on the motor. The effect is not the same at every system power factor, but is more pronounced at the lower values. In general, increasing the system kva. load decreases the change in system power factor by changing the load on the motor. This holds true for all cases where the size of the motor is small compared to the system's load.

The size of the motor affects the changes in the system power factor, owing to changes in the motor load. The larger the motor on a given system, the greater are the changes in the system's power factor, due to changes in the motor's load.

The design proportions of a motor affect indirectly the changes in the motor load. For example, in Fig. 1 the unity power factor motor takes 35 per cent of its rated kva. at no load, which will give a certain corrective effect to the system's power factor. Another unity-power factor motor of the same size but of a different design might take 40 per cent of its rated kva. at no load. This motor at no load would have a greater corrective effect on the system's power factor than the motor that takes only 35 per cent of rated kva. at no load. In the foregoing the discussion has been based on motors of equal kva. rating. If motors of equal horsepower were considered, the results obtained would be somewhat different, although the general conclusion, as previously expressed, will be found to hold true.

Gears for Power Drives

JUST who was the prehistoric engineer who worked out with stone or bronze implements the first crude set of gears is unknown. But as far back as written records go, gears have been in use for the transmission of power; among the first uses was the driving of water-lifting machines in the Nile Valley.

Gears may be conceived as wheels rolling on each other; this is actually the case with friction gears, as appears from Fig. 1. It requires no argument to prove that if no slipping takes place, the r.p.m. of such wheels are in inverse ratio to their radii or to their diameter; thus the r.p.m. of A is to the r.p.m. of B as diameter d is to diameter D.

Slipping does occur, and for this reason the placing of teeth on the two wheels becomes necessary when a definite speed ratio is desired. The plain wheels are then replaced by toothed gears, as shown in Fig. 2.

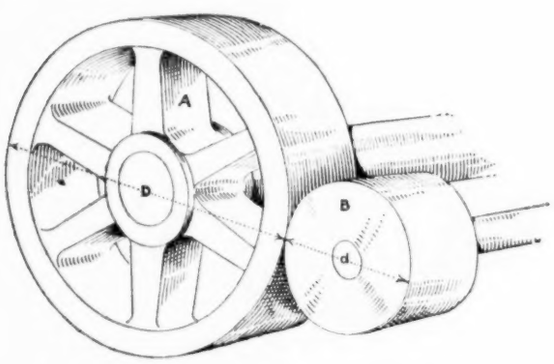


Fig. 1—Friction wheels are toothless gears

No doubt the original gear was made of wood, possibly a section of a round tree trunk, into which were driven teeth to engage similar teeth on another wheel. Until the smelting of iron became an established industry, so making cast-iron gears available, wood was widely used for gears of as much as 20 ft. diameter. Even in the last century many such gears were made for use with waterwheels. Wood wheels possessed several desirable qualities, for while not having a high tensile stress, they did have remarkable shock resistance. In addition, the breaking of a tooth was quickly remedied by the insertion of a new one.

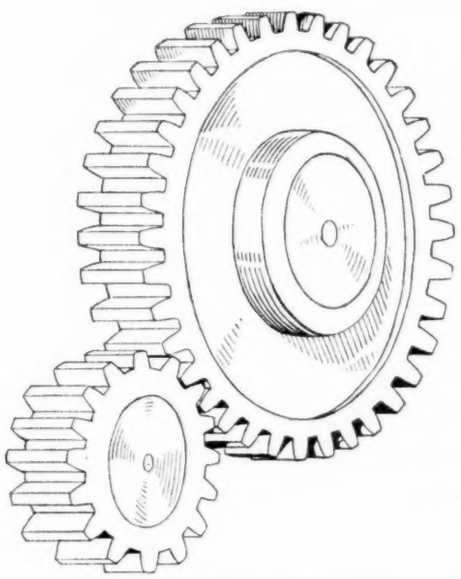


Fig. 2—Typical spur gears

For many years after cast-iron gears came into general use, the teeth were cast with the wheel. The teeth suffered shrinkage strains when cooling in the mold and, to insure strength, were made heavier than would have been needed in a more perfect casting, and the inequalities in the tooth outline made cast teeth very noisy.

Present-day gears used for all save the rougher work, such as conveyors, crushers, etc., are provided with teeth machine cut from the blank rim of the wheel.

The material may be of cast iron, cast steel, forged steel, bronze, etc. The tooth is given an involute contour, this being the curve generated by a point on a cord being unwound from one circle onto a second circle.

Suppose a cord is fastened at points on two wheels *a* and *b*, as shown in Fig. 3*A*. If the wheel *b* is turned the cord will move in a straight line from *c* toward *d*. This motion will cause the wheel *a* to rotate with the same rim speed as the wheel *b*.

If a piece of sheet brass be fastened to the underside of the wheel *a*, by turning the wheel *b* in the direction shown, the strap being kept tight by the resistance of

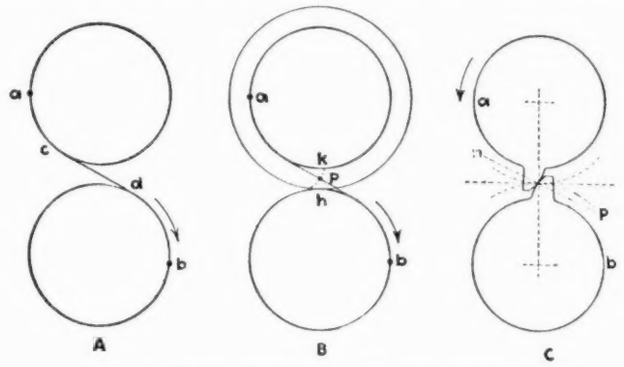


Fig. 3—How involute teeth are developed

wheel *a*, the point *p* will trace on the brass plate the curve from *p* to *h*, but if the disks are moving in the opposite direction, the point will trace the curve from *p* to *k*. A similar curve will be produced if another brass plate is placed on the second wheel. By filing away the metal of the disks, the two curves may be made to match together, as in Fig. 3*C*. Turning the wheel *a* in the direction of the arrow will give motion to *b*, and both wheels will move with the same speed in exactly the same manner as if they were connected by the strap, as shown in Fig. 3*A*, giving a uniform velocity. This involute is the form now in general use for gear teeth.

Developed Involute Tooth

It, however, calls for a special milling cutter for each diameter of gear. To avoid this the "developed" involute tooth was designed. By this system a single gear, which is in outline the shape of the pinion that would mesh with a rack, is used to cut the teeth of gears of all diameters. The work is done on a gear shaper, special machines being built by various tool manufacturers; this is the type of gear used in automobile and other light transmissions, but for the usual machine found in power plants the plain involute gear as cut on a milling machine, is more often used.

Even machined teeth cannot be made to come into engagement without some jar; consequently, there is more or less wear on the teeth. To reduce the noise of tooth contact and at the same time eliminate more or less the wear on the larger and more expensive gear, various forms of fiber pinions have come into general use. For heavy work pinions are often cut from a blank made up of layers of rawhide. The rawhide teeth are more yielding than are iron and steel teeth, so adapting themselves to any inequalities existing in the other teeth. This makes the contact clear across the face of the teeth instead of localized at one point, as is often the case when metallic teeth are incorrectly cut or the gear improperly aligned. A still greater advantage, at least in buildings where noise is objectionable, is the greater freedom from gear noise given by the rawhide pinion.

The practice in building up a rawhide pinion is to compress layers of the material between two metallic plates, usually bronze. If desired, the teeth can be cut before the plates are set, using temporary clamping flanges, and thin uncut plates put in place to make a shrouded gear as shown in Fig. 5. The usual practice, however, is to continue the teeth through rawhide and flanges, as shown in Fig. 4. The pins that clamp the plates are generally riveted rather than screwed. The keyway is then cut and the gears are ready for duty.

Other Materials Used

Muslin pinions, made up of layers of cotton cloth saturated with a bonding agent, are coming into use for both heavy and light work. They have to a greater degree the objection possessed by the rawhide gear, of changing shape and strength under adverse weather conditions. However, in indoor work such as on motor-driven power pumps, automatic mechanisms, etc., the muslin pinion is very satisfactory. Bakelite gears are largely used for such work as the timing gears of automobiles and small pump drives. This gear consists of layers of fiber impregnated with Bakelite; no end flanges are needed, as the material has considerable tensile strength and will support a keyway; the Micarta is another gear of the same general characteristics.

The problem the plant engineer faces in ordering a set of spur gears is by no means complicated. It is not necessary to know all the technic of how a gear is cut. He should know, however, the simple terms used in describing gears and the method of determining the diameters, number of teeth, etc.

The distance in inches between the center line of two adjacent teeth in a gear as measured along the pitch circle is called its circular pitch. As an example, a gear

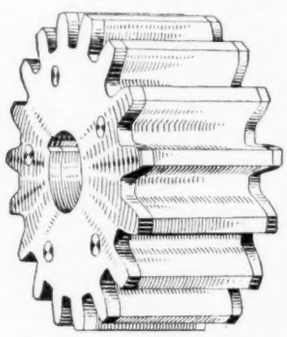


Fig. 4—Rawhide pinion with teeth in flanges

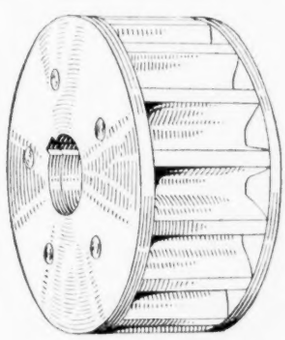


Fig. 5—Pinion with shrouded flanges

having 36 teeth set 1 in. apart has a 1-in. circular pitch and is 36 in. in circumference at the pitch circle; the diameter is then 11.45 in. Cast gears are usually designated in terms of circular pitch, but machine-cut gears are almost always classified in terms of diametrical pitch. For example, if a cut gear has a 10-in. pitch diameter and has 20 teeth, it is said to have a pitch number or diametrical pitch of 2.

In ordering gearing, the distance between the two shafts must be known, as must also the shaft speeds desired. If, for example, the distance be 24 in. and the speeds are to be 200 for the driving and 300 for

the driven shaft, calling the driven gear diameter D and the driving d, we have

$$D + d = 2(24) = 48, \frac{D}{d} = \frac{300}{200} \text{ or } d = \frac{2}{3} D$$

Substituting the value of d in the first equation, we have $D + \frac{2}{3} D = 48$, or $D = 28.8$ and $d = 19.2$. If the diametrical pitch is to be 2, one gear will have 57.6 teeth and the other 38.4. It is obvious these are impossible values and the nearest whole numbers would be 38 and 58 teeth, making the diameters 29 and 19 in. The speed of the driven would be $\frac{29}{19} \times 200 = 305$ r.p.m. It will be seen that one cannot always obtain a desired speed relation when the centers are fixed. Furthermore, in specifying gears it is well to remember that with usual tooth design one cannot use a pinion of less than 12 teeth without causing cramping where the teeth mesh.

In addition to the shaft center and desired speed relation, one should also specify as near as possible the horsepower to be transmitted, the particular service to

Fig. 6—Internal gear and pinion

be done, such as driving triplex pump, generator or coal conveyor. If the space is limited, mention should be made of the permissible maximum width of the gears. The shaft diameters are essential, as are also the dimensions of the shaft keyways.

The same dimensions must be known in case of internal gears, such as illustrated in Fig. 6. In this case the distance between shafts is not one-half the sum of the gear pitch diameters, but one-half the difference.

In addition to the theoretical advantage of a belt drive equipped with a weighted idler which increases the arc of contact of the belt on the pulleys, there is an important practical advantage in that tension once adjusted is automatically maintained. A straight belt drive may be set for the proper tension at the start, but gradually gets loose as the belt grows old. Another point worth considering is that the increased arc of contact permits the belt to run with less tension and hence with less pull on the bearings.

Damper Regulator and Balanced Valve Replace Reducing Valve

By C. M. Dilts

Some time ago we increased the boiler pressure in our plant from around 130 to 155 lb., and to supply steam to a certain section of the plant where the pressure of 125 lb. had to be maintained, we installed a standard pressure-regulating valve in a 4-in. line.

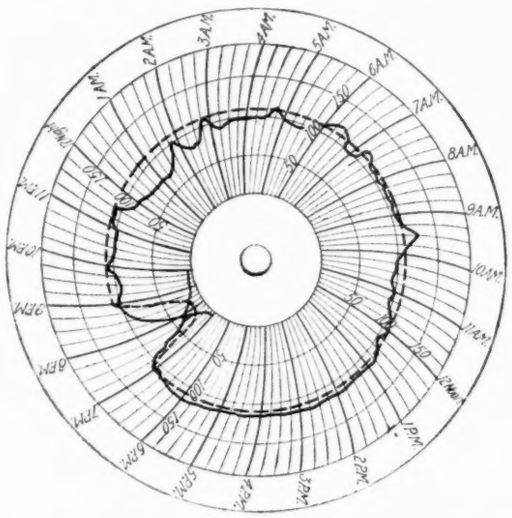


Fig. 1—Pressure chart from low-pressure line before and after making change

As there was a wide variation in the steam demand of the various services supplied with steam from this line, the results obtained with this valve were far from satisfactory, the pressure varying considerably, as shown by the solid line on the chart Fig. 1. In an endeavor to overcome this variation, we replaced the reducing valve with a hydraulically operated regulator and balanced valve, as shown in Fig. 2. With this equipment a big improvement has been made, and the pressure is now practically constant, as shown by the heavy dotted line on the chart Fig. 1.

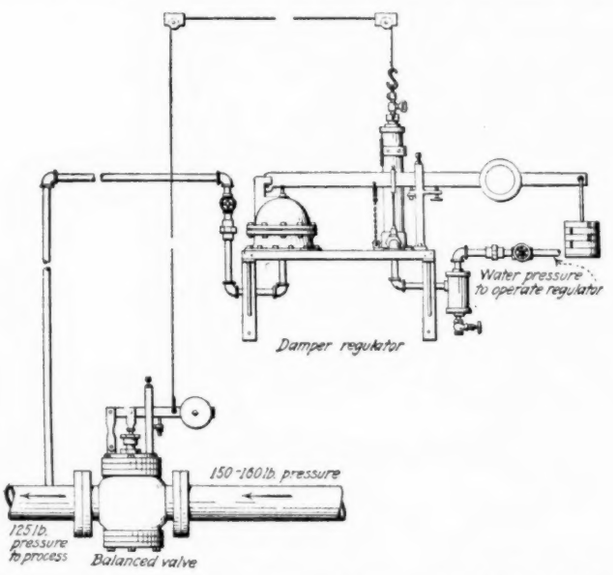


Fig. 2—Arrangement of regulator and balanced valve

Will Regulation Be the Solution?

THE conference of coal operators and miners became deadlocked and broke up last week without getting any nearer to a solution of their differences. Each side hurled a broadside of accusations at the other, but from the statements of neither could any lucid idea be gained of what actually transpired in the conference. Meanwhile the strike continues, stocks are getting low and cold weather is here.

Settlement and readjustment through economic pressure is always preferable to federal or state interference. Where such measures fail, however, the alternative may become necessary. While there may be some question of federal jurisdiction, as was evidenced by the President's request of Congress for authority to deal with such an emergency, there can be no question of Pennsylvania's jurisdiction.

Almost simultaneously with the breaking off of negotiations between operators and miners, there comes up before the special session of the Pennsylvania Legislature a bill declaring anthracite a public utility and providing for regulation of the industry on that basis.

There are people who are quite willing to split hairs in arguing against the classifying of anthracite as a public utility. Nevertheless, in the broader sense it is as much a public utility as gas or electricity. While it is true that the public can burn substitutes for anthracite, so can they use kerosene or candles in place of electricity or gas. State regulation has proved a good thing for the utilities as well as the public served. Might it not likewise prove beneficial in the case of anthracite?

Valve Stem Packings

ONE seldom sees a leaky joint in the pipe flanges of a modern power station even when high pressure and superheat are used. On the other hand, one frequently finds valve stems leaking badly and this is particularly noticeable on the smaller valves such as those on drip lines. This troublesome feature proves very annoying to the operators, for it is frequently not easy to shut down to renew the packing. This does not mean that there are no good packings on the market for certain conditions. Too frequently, these packings are used under unsuitable conditions and are unjustly condemned.

Packing difficulties have multiplied with increasing pressures and temperatures. One frequently hears a chief engineer remark that he has tried this and that packing, but none has been entirely satisfactory. He either is still experimenting or has standardized on the packing that seems to give him the least trouble. The nuisance of steam leaks and the resultant loss of heat and makeup would seem to warrant some of our research organizations in taking up this whole question of valve-stem packing. The requirements for such material could be analyzed, and experiments may develop certain fundamental characteristics that are necessary in packing materials for various conditions. Engineers could then specify some definite style of packing for each condition with the assurance that it would stand up to its job better than other available material.

Standardization has been beneficial in improving quality and decreasing costs in other lines. The same results might be expected if packings were standardized. These considerations would indicate that such a research could result in profit to both packing manufacturer and user. The former would save money by standardized production and the latter by the use of the best material. What agency will undertake this research?

The French Exchange Professorship

ONE of the essential aims of education is the development of a sympathetic grasp of the accomplishments and spirit of our fellow-men in other lands. This can be promoted through the printed page, but at its best reading is a poor substitute for personal contact.

For some years there have been a number of scholarships under which students may study in foreign lands. Rhodes scholars from America study in England. Chinese and European students come to the United States under various auspices. All this is splendid for the fortunate students, and through them, for their native countries.

Another plan which has proved of great value is the establishment of exchange professorships, under which forthstanding men spend some months among foreign universities, while men of like ability come from Europe to visit our schools, lecturing and meeting students and faculty face to face. This makes it possible for thousands of students to come into personal contact with men of conspicuous ability from other lands, and in some measure to become acquainted with their points of view and methods of thought. The specific information imparted by such a man is of small consequence—that can be done at less cost through books; the important thing is that the student shall know a leading thinker of another nation and gain some comprehension of how and what he thinks. This is invaluable to our national life, with its increasing dependence upon international understanding.

For a number of years seven American Universities —Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, University of Pennsylvania, and Yale—have been exchanging professors with the universities of France. Eminent men have come to this country from France, and some of our intellectual leaders have visited France.

Owing to unfavorable exchange, the appropriation of twenty thousand francs on the part of the French universities has dwindled so much that last year the exchange of professors almost ceased and was effected at the last moment only by securing a professor for a few weeks, whereas in the judgment of all the usefulness of the exchange depends upon the ability of the French exchange professor to remain from three to four weeks at each university. To effect the full exchange and to secure the great benefits that all desire, there is needed an annual sum of five thousand dollars for the incoming professor, the American universities having shared the expense of the outgoing professor.

An effort is being made to secure contributions from those who may be interested in aiding the cause of education in this country, and the American Society of Mechanical Engineers is assisting in the campaign through the activities of its Secretary, Calvin W. Rice.

Power appeals to its readers who are able and interested to send their contributions to Mr. Rice.

Measuring Efficiency by the Losses

IF A MAN set out to walk from one point to another approximately one mile away, but failed to reach his destination by a few hundred feet, his "efficiency" in covering the distance might be taken as the ratio of the distance covered to the distance attempted.

After measuring the total distance attempted, the distance covered could be found in either of two ways. The obvious way would be direct measurement, but a more accurate final ratio would be obtained by measuring the remaining distance and subtracting it from the total to get the distance covered.

This is one illustration of the well-known principle that, assuming an equal percentage of error in all measurements, efficiencies greater than fifty per cent can generally be determined with less error by taking the output as the input minus the losses, rather than by direct measurement of the output.

Important applications come in the testing of such high-efficiency apparatus as modern boilers, electric motors, etc. The higher the efficiency the more can be said for indirect determinations of efficiency, making due allowance—in the case of boilers—for the fact that flue and other losses cannot generally be measured with as high a percentage of accuracy as output. The indirect method of testing has considerable commercial importance, as it is often feasible where direct measurement of output by accurate methods would be prohibitively expensive.

Why All the False Doctrines?

WATER power has been subjected to more false doctrines than all our other natural resources combined. Notwithstanding this, water power continues to attract a large amount of public attention. If this were based on a sound economical appraisal of the facts, instead of on all kinds of cheap-power propaganda, hydro-electric development might stand in an even more favorable position than it does at present. What is needed in legislative halls, in the public press and even, in some cases, among engineers is a true appreciation of the economic value of water power. On one hand there is preached the conception of cheap power, produced from waterfalls, which will revolutionize our present civilization, and on the other side the equally false doctrine that water power is now and always will be an inconsequential factor in the country's power supply.

Important as power is in modern industry, it is in general one of the smallest items of cost, representing on an average only about two per cent. There are a few industries where power represents a considerable percentage of the total costs, but these are the exception and not the rule. In a number of the important industries power is only a small fraction of one per cent of the total cost of production. These simple facts should make it plain that something more than reducing power costs is necessary to decrease materially the costs of most products. Power is one of the cheapest things purchased by the public. With the increased costs of labor and materials and the depreciated value of the dollar, the average cost per kilowatt-hour is about the same as it was ten years ago. For the small consumer the cost has been reduced on an average of over one cent per kilowatt-hour.

Power delivered on the busbars of a hydro-electric plant is frequently much cheaper than that produced in large steam stations under the most favorable conditions. However, if this power must be transmitted one or two hundred miles to get it to the consumer, the cost may approach that of power produced from fuel.

All this does not affect water power as an important factor in the nation's power supply. During the last year about one hundred and seventy-five million dollars was invested in steam plants by central-station companies in this country. In this same period these companies spent over one hundred million dollars in hydro-electric plants. During the last three years over thirty-six per cent of the power generated by these companies was produced in hydro-electric plants.

These figures show that water power will always be an important factor in the power supply of this country. But why not be rational and treat this national resource as we do others of equal importance?

Savings Invisible But Important

CERTAIN important savings—such as those due to adequate heat insulation, improved lubrication and, in particular, better working conditions—are hard to demonstrate in a manner direct enough to satisfy the user. Yet they may actually be out of all proportion to the cost. In the case of heat insulation the data produced by extensive and painstaking research work make it possible to compute the return on the investment with considerable accuracy.

As thus computed, they generally equal the cost of the entire insulation job in six months' time or less. That is, an investment in heat insulation generally yields about two hundred per cent yearly—astounding, but true! Yet these savings, being but a small fraction of the coal bill, may be so buried in the fluctuations of other items as to be invisible. An investment of one thousand dollars in heat insulation may actually save two thousand dollars per year, but the seller naturally cannot promise that if the coal bill is one hundred thousand dollars this year it will drop to ninety-eight thousand dollars the next. Circumstances beyond his control might easily push it to one hundred and ten thousand dollars.

The difficulties of direct demonstration are even greater in the case of lubrication, while such savings as those due to the improved morale of firemen provided with shower baths are the most elusive of all.

Practical Ideas From Practical Men

Boiler-Water Level Drops

In a heating plant connected with a school the night fireman allowed the fire to go out. As soon as he awoke and found the steam gage registering zero, he closed the steam valve at the top of the boiler in order to raise steam quickly, and started the fires. In a few minutes the water level dropped down so that not only did it disappear from the glass, but water would not run out of the column drain. He pulled the fires and in 10 or 15 minutes the water reappeared. On rebuilding the fire, the water again disappeared. The performance was continued several times until the day man came on the job, who relieved the night man and proceeded to get things going. He had no trouble in getting up steam and claimed he had only built the fire and had made no change in anything. When called to the attention of one of the instructors, the variation in water level was pronounced an impossibility.

It would be interesting to have other engineers outline what they think was the cause.

St. Louis, Mo. G. GROW.

Why the Vacuum Was Low

A 1,500-kw. steam turbine in one of our plants had been operating apparently with a vacuum of 28 in., as indicated by the gage. Connecting a mercury column to the condenser revealed the fact that the vacuum was actually only 27 in. when the gage indicated 28 in. This immediately led to a search for the cause of the low vacuum.

The condenser, which is the low-level jet type, was examined for air leaks and the seats of the atmospheric relief valve reground. The speed of the condenser pumps was checked and found to be correct. In going over the manufacturer's specifications for this unit, it was noted that the condenser capacity was specified on the basis of an injection-water temperature of 75 deg. F. It was found that in actual operation the temperature of the injection water at the inlet was 84 deg. and at the discharge 106 deg. Reference to the steam tables indicated that the temperature of saturated steam for 28 in. of vacuum (referred to a 30-in. barometer) is 99.9 deg. and for 27 in. of vacuum 112.5 deg. F. Since most jet-condenser designs are based on a 5-deg. terminal difference as between steam temperature and discharge-water temperature, the steam was being condensed at an approximate temperature of 106 plus 5 = 111 deg. As this is practically the temperature of steam at 27 in. vacuum, it can be seen that with the stated conditions of injection-water temperature and a fixed condenser capacity, it was impossible to attain a better vacuum on the unit with full load.

Reference to the manufacturer's data showed that the capacity of the condenser decreased from 26,600 lb. of steam per hour to 20,500 lb. of steam per hour with an increase in the injection-water temperature at inlet of from 75 to 80 deg. With a temperature of 84 deg. it is estimated that the capacity of the condenser is reduced to 16,000 lb. of steam per hour maintaining a vacuum of 28 in. Since the water rate of the turbine at full load is 17.5 lb., it is evident that the condenser capacity is sufficient with an injection-water temperature of 75 deg. to maintain a vacuum of 28 in. This follows from the fact that the capacity is 26,600 lb. per hour and the steam used at full load 17.5 $\times$ 1,500 = 26,250 lb. It is also evident that at full load on the unit the greatly decreased condenser capacity due to increase in temperature of injection water made it impossible to secure 28 in. of vacuum on the unit.

As this turbine usually operates on a base load in parallel with hydro-electric plants, it was found desirable to run tests on the unit at various loads to determine the most economical load and to operate on this load whenever possible. FREDERICK KRUG,

Supt. of Power Production,
Porto Rico Railway, Light & Power Co.
San Juan, Porto Rico.

Remetaling Babbitt Bearings

The operation of remetaling babbitt bearings is by no means a simple one; each step must be well understood and properly performed to obtain the best results.

Experience has shown that a perfectly good babbitt can be made practically worthless for bearings by allowing it to become too hot, also by pouring when too hot or too cold, yet sufficient attention is not given in many instances to the proper handling of the babbitt in melting and applying it to the bearing.

To renew babbitt bearings effectively, it is necessary to remove all the old lining from the shell by heating, preferably in a pot of molten scrap babbitt kept at a temperature of about 675 deg. F. Immediately the old lining is melted out, swab the bearing surface with zinc chloride and then dip the shell into a pot of molten "half-and-half" solder, which should be kept at a temperature not less than 625 and not more than 675 deg. F. Babbitt metal should not be used for tinning because it has a much higher melting point, which makes it difficult to maintain a molten film on the bearing surfaces. The shell should be left in the molten solder until it is just hot enough for the solder to run off freely, leaving a thin coating on the surface.

Occasionally, it is found when a bearing lining has been melted out, that the surface contains black spots or streaks; these should be removed by scraping or filing before tinning the shell. When the bearing surface is properly cleaned, cover the parts not to be tinned with claywash or a thin mixture of graphite and water. Swab the bearing surface with the zinc chloride and then tin the shell by immersing in the molten solder. The best material for wiping the shell bearing surface is closely woven cotton fabric that is free from nap. Ordinary cotton waste is unsatisfactory, as it tends to leave strands upon the tinned surface, which are difficult to remove. The bearing to be babbitted should

be done immediately after it has been tinned before losing the heat given to it during the latter process.

Dealing now with the babbitt metal itself, care must be taken not to overheat it during the melting operation, as an overheated babbitt is more or less brittle. The correct temperature is from 850 to 875 deg. F. It is necessary that this temperature be maintained when pouring the metal and that the higher temperature be not exceeded. Before pouring, the molten metal must be thoroughly stirred, preferably with a stick of wood; otherwise the heavy metals will settle at the bottom of the pot. To prevent oxidation of the molten metal, cover it with a thin layer of powdered charcoal.

Wherever practicable the bearing shell should be in a vertical position while pouring. The bearing should be mounted in a jig and both heated until the tinning on the inner surface just begins to run. Pour from the ladle in a steady stream directly down along the heated mandrel to avoid pocketing of air or splashing. A well-designed ladle for the job is one having a rounded spout to enable the babbitt to be poured in a round and smooth stream. If the lip of an ordinary ladle is used with rough burrs or other surface irregularities, the metal is splashed up against the mandrel, which tends to produce porous surfaces or blowholes. Properly remetaled bearings should ring when struck lightly with a hammer; if they do not, it indicates that the babbitt metal has not adhered thoroughly or that the bearing is cracked.

E. ANDREWS.

Manchester, England.

Return Trap vs. Steam Pump for Boiler Feeding

Frequently, some rather strong statements are made by manufacturers of power-plant equipment, which are not borne out by the actual performance of their product. Plant managers, having no technical training, often purchase something on the strength of salesmen's statements regarding the savings that will be effected by it, and when it falls down, they are henceforth prejudiced and skeptical even against practical plans suggested by the operating force. Remembering only that they once spent several hundred dollars for an article that did not earn its cost, they place all other new devices in the same category, even those that have proved to be essential to economical operation.

For instance, a pamphlet sent me recently by a trap manufacturer contained statements that were not based on sound engineering principles and were clearly meant to push sales. One paragraph read, "As the pump has replaced the injector for boiler feeding, so will the trap replace the pump in large plants. Over 95 per cent of the steam supplied to a direct-acting steam pump is wasted in the exhaust, and this heat cannot be recovered, hence the wastefulness of the pump, while all the steam used in the operation of the . . . trap is returned to the boiler in the feed water." Now since thousands of plants use the feed-pump exhaust to heat the feed water, where is the basis for this statement?

Another trap salesman came into my plant one day to discuss a trap installation on our paper machines. Condensate at 10-lb. pressure (240 deg. F.) was to be returned direct to the boiler by means of a pumping and return trap. Our feed-water temperature was 220 deg. when fed by a pump through a closed heater, the heating being done by the exhaust of the feed pump and jet condenser pump. I was told that the trap would return condensate to the boiler at 240 deg. or higher with no loss of heat units (condensate now mixing in receiving tank with cold makeup water). He next showed me a piping layout for a 2½-in. trap, and according to the instructions for installing, a vent leading to the atmosphere was open when the trap was in the filling position. When the trap tilted to discharge the water, the vent closed and high-pressure steam was admitted. When empty, it returned to filling position and the vent opened automatically to discharge the steam, remaining open until the trap again filled. Now how could the condensate remain at 240 deg. in the trap with only atmospheric pressure on the trap? Is there not a waste of 28 B.t.u. per pound of condensate handled (240-212)? Also a further loss when a trapful of steam at 120-lb. pressure is released to the atmosphere? The only way the condensate could enter the boilers at 240 deg. is by the use of live steam to heat it from 212 to 240 deg. during the process of discharging the water from the trap. According to my ideas the relative loss of heat units in the two systems is as follows:

With 5,000 lb. of condensate per hour to be handled, the loss through the vent when open to the atmosphere is 5,000 (240-212) or 140,000 B.t.u. per hour. This is equivalent to $\frac{140,000}{1,003.6}$, or 139 lb. of steam per hour, 1,003.6 being the heat required to evaporate feed at 220 deg. into steam at 120-lb. pressure. The loss by venting a trapful of high-pressure steam to the atmosphere every time the water is discharged would be around 25 lb. of steam per hour for this particular trap. Thus we see that it takes 164 lb. of steam per hour to operate the trap. With a pump our average feed temperature would be much higher, as the condensate is mixed with the makeup, no heat units being lost.

Assuming a steam rate of 80 lb. for the feed pump and 50 per cent efficiency, the power required to pump 5,000 lb. of condensate is 2.8 hp., or 224 lb. of steam per hour. But approximately 97 per cent of this 224 lb. of steam is reclaimed in the heater, so only 3 per cent, or about 7 lb. of steam, can be charged against the pump, all the heater condensate returning to the receiving tank. Our total load being 18,000 lb. of steam per hour, there would be 13,000 lb. of makeup to be heated by the other pump alone if traps were used, and since 224 lb. of steam would be diverted from the heater, the temperature would drop about 20 deg. So with 5,000 lb. at 240 deg. and 13,000 lb. at 200 deg. the average temperature of the feed water would be approximately 211 deg. F. As no exhaust steam except from the pumps was available for feed heating, the operating costs would have been increased by using a return trap for feeding. I suggested that the trap should vent to the heater, but the manufacturer claimed that this was not common practice and stated that all their installations were made as outlined here, claiming that great savings had been made in other plants. But even if we credit the trap with the difference between 224 and 164 lb. of steam per hour (an apparent saving of $60 \times 1,003$, or 60,180 B.t.u. per hour), the operation of the trap entails a loss of 162,000 B.t.u. per hour due to the drop in feed temperature from 220 deg. to 211 deg.

Naturally, the trap installation was never made, as it was not the proper thing for this particular plant.

Brightwood, Mass. ANDREW F. SHEEHAN.

Comments from Readers

Partial Vacuum in Heater Caused Pump to Pound

Referring to the letter in the Nov. 3, 1925, issue by R. N. Ottman regarding pump pounding caused by a partial vacuum in his heater, I have experienced the same trouble.

The plant in question contained one 26x48-in. and one 20x36-in. Corliss engine, the exhaust pressure being 6 lb. The exhaust steam passed through a heater to heating coils for a large brick drier. Two 7-ft. fans pulled cold air through the coils and discharged it to the drier. Now if the load dropped off suddenly, the cold air passing through these coils would cause a vacuum to be formed in the coils and heater and the boiler-feed pump would pound, as the temperature of feed water ran around 226 deg. The only way we could stop the pounding was to stop the pump temporarily. All condensation from the exhaust lines was returned to the heater by a return trap, the heater being placed about four feet above the pump.

To overcome this trouble I put a 1¼-in. swing check at the top of the heater to act as a vacuum breaker, and I also ran a 1¼-in. pipe from the suction at the pump to the steam space of the heater to equalize the pressure. After these were put in use, we had no more trouble with the pump pounding. L. A. COLE.

Columbus, Ohio.

America Already Uses a Decimal System

Referring to the letter of H. D. Fisher in the Dec. 15, 1925, issue on "America Already Uses a Decimal System," he apparently offered himself as a witness for the defense in championing the English system of measures, but isn't he really in the position of an unwilling witness for the prosecution? The facts that the Baldwin Locomotive Works use the inch as unit, ignoring feet, and that surveyors use the foot to the exclusion of the inch, indicate that the present system leaves something to be desired. Should every industry have its own pet system of measurement which it uses in groups of tens and hundreds and which the public must consider in groups of 12 to 5,280 or other awkward figures?

We measure the dimensions of a grate in feet and inches, but grate area is frequently mentioned by some such figure as 429.7 sq.ft. Why not 429 sq.ft. plus 100 and 31 sq.in.? The idea is repulsive. If we think easily in decimals of a unit, would not it be convenient to measure in decimals of that unit?

That the automobile industry starting "fresh" did not adopt the metric system, proves nothing, because it did not start fresh, being handicapped with machine tools calibrated in the antequated system. It suffered because of the sins of past generations. The electrical industry more nearly started "fresh" and made the metric system the basis of its units—volt, ampere, etc. Magnetic flux calculations are made in the metric units and then converted into the old system when turned over to the manufacturing and where the dead hand of the past presses down.

Take a sample to the chemist for a quantitative analysis, and he will do his weighing in grams. If it is a water analysis, he will give you the results in grains per gallon and its one kind of gallon in the United States and another in England, and it might be mentioned that the variation in the gallon is greater than the temperature variation mentioned by Mr. Fisher.

The decimal system has admitted advantages, and for calculations of refinements the metric units have advantages. Why not go "whole hog" and take the entire system instead of making a new decimal arrangement of the English system? Is inertia, hardening of the mental arteries and a sentimental longing for such words as pennyweights, furlongs, puncheons, long tons, cords, hands and stones sufficient reason? E. S. SMAIL.

Oak Park, Ill.

Are Welded Pressure Tanks Safe?

In the Nov. 10, 1925, issue there are two editorials that evidently were put together from plan because I cannot imagine luck doing it so well.

The first one is "Getting It Across," which brings out the fact that conversation is a good deal more valuable than knowledge for an engineer or a pseudo engineer to possess, and the other is asking the question "Are Welded Pressure Tanks Safe?"

It is, however, in connection with the welded pressure tanks being safe or unsafe that I would like to comment. There has never been any question as to whether welded tanks have been safe or not; there has also never been any question as to whether a tank that is stuck together by an improper weld is unsafe. The only question is whether a tank that is supposedly welded has been welded or not.

We are passing through the same period at the present time in connection with arc welding as we passed through twenty-five years ago in connection with the use of concrete, or one hundred years ago in connection with the railroad, or twenty years ago in connection with the automobile. Our conversational engineers have in connection with all these developments learnedly come out with the statement that they are impossible of use and are unsafe. The statute books of all the states are spread over with laws and rules in connection with railroads, concrete construction and automobiles, which in the light of present fact are, to say the least, humorous. Ten years from now asking a question such as your editorial asks, "Are Welded Pressure Tanks Safe?" will be just as funny as the law on the statute books of Connecticut which was passed some ninety years ago limiting the speed of locomotives to twelve miles an hour.

There is no difficulty in getting welds that are just as reliable as the steel out of which the welds are made; there is no difficulty in making sure that the joint con-

structed by welding is just as strong and just as accurate in its strength as a riveted joint made alongside of it. These facts are ready for anyone to investigate who is sufficiently interested, and I think it is safe to say that at the present time there are at least a half dozen manufacturers of welding equipment who would be perfectly willing to guarantee to weld up any kind of tank and test it at a pressure that will rupture any riveted tank made of the same thickness of material, and pay for every case of break that occurs during the life of the apparatus he furnishes. This has been true for years, although there are a great many pseudo engineers who are not acquainted with the progress in their art to do any more in connection with arc welding than to call attention to its growing pains.

I wonder if these same engineers would feel that people who wish to criticize them would be justified in taking their actions at the age of seventeen as a correct indication of their abilities at forty-five.

J. F. LINCOLN, Vice-President,
Cleveland, Ohio. The Lincoln Electric Co.

Underfeed Stoker Performance at the Memphis Power & Light Plant

Some months ago an interesting article appeared by E. H. Tenney, relative to pulverized-fuel burning equipment at the Ashley Street station, St. Louis. In this article comparative results were shown between pulverized fuel and underfeed stokers which appeared

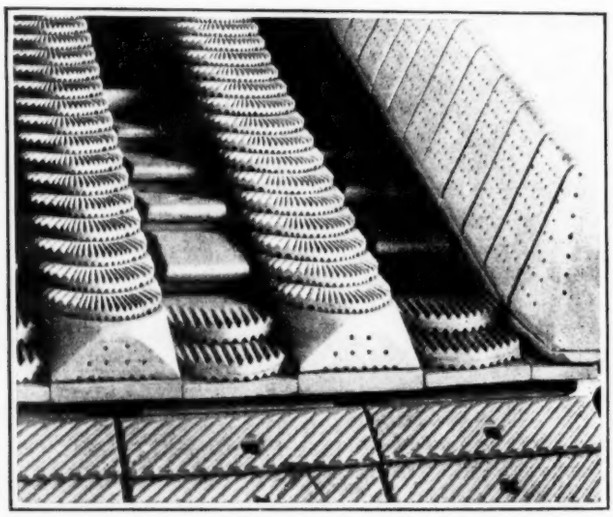


Fig. 1—Shallow retort at lower end of stoker

very favorable to the pulverized-fuel unit. However, it must be remembered that this pulverized-fuel furnace has been recently installed with a much larger furnace volume, water-cooled side walls, and a rearranged boiler baffling, while the stokers used in comparison were designed many years ago and have been in regular service eight years. In view of the previous article showing comparison of operating results, it is felt that engineers will be interested in the results obtained at the plant of the Memphis Light & Power Co., Memphis, Tenn., with a new-type underfeed stoker burning a low-grade fuel.

The coal contained from 14 to 16 per cent ash (dry basis) with a fusing temperature of about 1,900 deg. F. The boilers are 15,120 sq.ft. cross-drum, set 17 ft. above the floor line. The furnaces have no circulating tubes in either the side walls or bridge walls, no air preheaters and no economizers. The stokers are 13-retort underfeed, one being equipped with a double-roll clinker grinder, and three with double-dump grates.

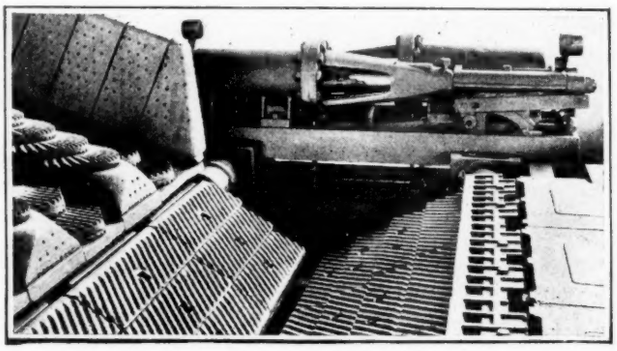


Fig. 2—Operating position of dump grates

The series of tests shown in Table I were conducted on the clinker grinder stoker, while those in Table II were made on the dump-grate stokers.

TABLE I—RESULTS OF TESTS CONDUCTED ON STOKER WITH CLINKER GRINDER

Test number	1	2	3	4
Dates (1924)	April 9	April 10	April 11	April 14
Duration, hours	23¼	23¼	17¼	16¼
Pounds coal per sq.ft. grate surface per hour	25.1	36.8	49.2	74.8
Coal Analysis (Proximate)				
Moisture (as fired)	....	8.7	9.3	11.1
Volatile matter (dry basis)	37.2	37.0	35.9	36.7
Fixed carbon (dry basis)	46.4	49.1	49.1	48.8
Ash (dry basis)	16.4	13.9	15.0	14.5
Fusing temperature of ash	1,872	1,915	1,894	1,905
B.t.u. (dry basis)	11,892	12,132	11,994	12,014
Sulphur separately determined	4.61	4.58	4.24	3.90
Per cent combustible in refuse	9.2	9.2	9.0	13.9
Gas Analysis				
CO_2	14.40	15.43	16.08	15.29
O_2	3.82	2.20	1.81	2.82
CO	0.02	0.03	0.05	0.01
Boiler and furnace efficiency	83.2	82.1	81.0	79.0

TABLE II—RESULTS OF TESTS ON DUMP-GRATE STOKER

Test number	2	3	4	5
Dates (1924)	April 1	April 2	April 14	April 15
Duration, hours	10	10	16.75	10
Pounds coal per sq.ft. grate surface per hour	20.4	30.5	56.2	41.4
Coal Analysis (Proximate)				
Moisture (as fired)	7.4	7.2	7.5	7.1
Volatile (dry basis)	37.3	37.4	38.4	38.2
Fixed carbon (dry basis)	47.7	46.3	46.3	48.9
Ash (dry basis)	15.0	16.3	15.3	12.9
Fusing temperature of ash	1,915	1,915	1,894	1,905
B.t.u. (dry basis)	12,225	12,084	12,256	12,620
Sulphur separately determined	3.95	4.11	4.22	4.61
Per cent combustible in refuse	13.8	10.4	19.7	9.6
Gas Analysis				
CO_2	13.77	14.25	15.91	15.17
O_2	4.73	4.12	2.05	3.04
CO	00	00	0.050	0.024
Boiler and furnace efficiency	81.2	80.6	79.8	76.6

No attempt was made during these tests to weigh water and coal, other than calibrate the measuring devices, as the true measure of stoker performance is not necessarily the amount of water evaporated per pound of coal. This is a function of the boiler as well as the stoker. All efforts during these tests were concentrated on obtaining accurate data on the flue-gas analysis and the amount of unburned carbon in the refuse, these being strictly functions of the stoker. Sufficient readings were taken, however, to calculate a heat balance and the boiler and furnace efficiency shown in the tables.

The modern underfeed stoker has been designed with a long secondary ram and a shallow retort at the lower end of the stoker, as indicated in Fig. 1. This enables

the stoker to eject the clinkers from the lower end of the stoker onto the agitator. By varying the stroke of the secondary rams, the proper contour of the fuel bed can be maintained and the fuel bed kept well broken up, assuring a uniform distribution of air. The secondary ram control mechanism is of an entirely new design, and the stroke of all the rams can be controlled by a single lever. The stroke of the secondary rams can be varied from 0 to 6 in. in increments of 2 inches.

The front dump grate on the new stoker is known as the agitating extension grate. Fig. 2 shows the dump grates in the operating position, while Fig. 3 shows the refuse discharge position, the agitator being raised while cleaning the fire to prevent the possible avalanching of the fuel bed. Fig. 4 shows the dump grates in the agitating position. Both dump grates are operated by steam cylinders controlled by the pilot valves shown in Fig. 6. The advantage of using the front dump grate as an agitator lies in the fact that it provides a positive means of breaking up the mass of burning fuel and refuse as it is pushed down from the overfeed section onto the dump grates, thus permitting the combustible to be more completely burned out. This, together with the fact that the dump grates have wholly active fuel-burning surfaces, results in the combustible in the refuse being low.

The underfeed stoker equipped with the rotary ash discharge or clinker grinder is also a recent development when applied to Western fuels having a high percentage of ash with low fusing temperature. It has been demonstrated beyond doubt that coals of inferior grade which make soft, sticky clinkers can be burned

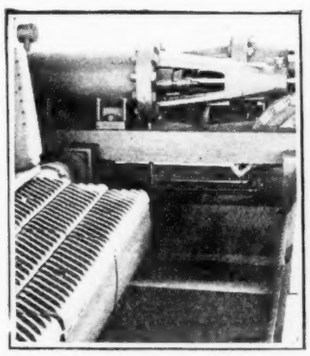


Fig. 3—Dump grates in discharge position

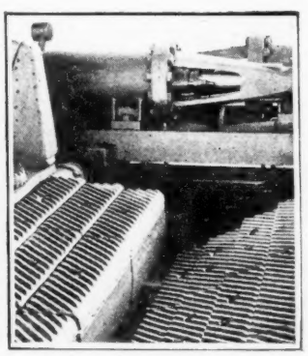


Fig. 4—Agitating position of dump grates

successfully on clinker-grinder stoker with a relatively higher efficiency and lower maintenance cost than with stokers equipped with dump grates. Fig. 5 shows a view of a modern underfeed stoker equipped with a clinker grinder.

Although numerous other changes have been made in the underfeed stoker within the last five years, the ones mentioned have enabled the stoker operators to maintain a fuel bed of the proper contour, to keep it well broken up, and to eject the clinker formations from the lower end of the stoker without any manual assistance on the part of the operator. This has resulted in a higher average CO_2 and a lower percentage of combustible in the refuse, while operating through all ranges of boiler ratings.

Furnace design has also radically changed within the last few years. More tube surface is being exposed to the radiant heat of the furnace, furnace volumes have been greatly increased, water-cooled side and bridgewalls are being adopted, the boiler baffling has been changed, and air preheaters are being installed.

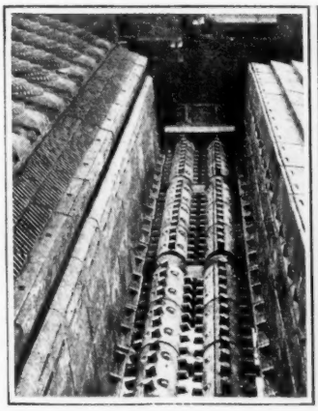


Fig. 5—Clinker grinder at rear of underfeed stoker

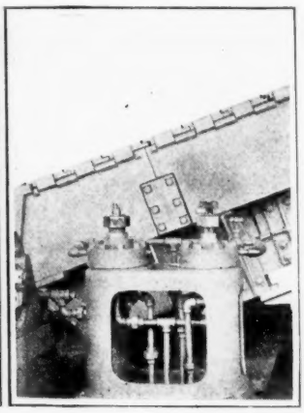


Fig. 6—Pilot valves control steam to operating cylinders

All these features have a beneficial effect upon both the efficiency and the capacity of the combustion system and should be borne in mind when making comparisons.

C. R. BURLINGAME,
St. Louis, Mo. Westinghouse Elec. & Mfg. Co.

Upholds the Hydrostatic Test for Boilers

In the Dec. 8, 1925, issue I read the article by Arthur Jones, in which he claims that hydrostatic testing of boilers is no good. I surely would like to have him or anyone else explain just how they are going to find the defects in a boiler with the eye of an experienced man and a small hammer. If that method has anything on the hydrostatic testing, then it is high time, in my opinion, that some other method of inspecting boilers was used.

I have been on steamships and have seen the inspectors testing boilers, and it was a real inspection that they gave them, and they did not have any old kind of pump either. It was a much more rigid test than is usually given by insurance inspectors that give the hammer and experienced eye test as mentioned by Mr. Jones.

I can recall a case not long ago where the inspector allowed 100 lb. pressure on two horizontal-return tubular boilers that were 38 years old, having ¼-in. plate, lap joints, double rivets, ⅞-in. rivets, tubes that had never been renewed, many of them pitted and corroded, as were also the shell plates. These boilers were used for heating only while the other boilers were being washed, but imagine allowing 100 lb. on boilers where the shell plates were less than ¼ in. thick in places! They should have been condemned years ago. At the last inspection a pressure of 60 lb. was allowed on them without any repairs whatever being made.

I can recall a number of instances where the inspectors passed equipment that should have been scrapped years before, whereas if they had given a hydrostatic test as is done by the marine inspectors, they would have accomplished something.

GEORGE M. JACOBS.
Duluth, Minn.

Questions and Answers

Conducted by

Franklin Van Winkle

Finding Boiler Heating Surface

I have two horizontal tubular boilers 72 in. in diameter by 18 ft. long, with seventy 4-in. tubes. Explain how to calculate the heating surface. F. P.

It is customary in case of horizontal tubular boilers to include in the square feet of heating surface the exterior surface of all the tubes plus two-thirds the exterior surface of the cylindrical shell plus two-thirds the surface of the two heads, minus the area of the tube holes in each head.

In the boiler cited the total area is made up of:

$$\text{Tube area} = 70 \times \frac{4 \times 3.1416}{12} \times 18 = 1{,}319 \text{ sq.ft.}$$

$$\text{Cylindrical shell area} = \tfrac{2}{3} \times \frac{72}{12} \times 3.1416 \times 18 = 226$$

$$\text{Head area} = \tfrac{2}{3} \times 2 \times \frac{72}{12} \times \frac{72}{12} \times \frac{3.1416}{4} = \frac{38}{1{,}583}$$

$$\text{Tube-hole area} = 2 \times 70 \times \frac{4}{12} \times \frac{4}{12} \times \frac{3.1416}{4} = \frac{12}{1{,}571}$$

Net heating surface, sq.ft.

Air Compression at High Altitudes

Does it require more or less work to compress 1,000 cu.ft. of free air to 100 lb. gage pressure when the atmospheric pressure is but 12 lb. per sq.in. absolute, as in the case of mountain power plants, than when the atmospheric pressure is that at sea level? P. G.

Assuming that the compressor is a single-stage unit, the theoretical work required to compress adiabatically 1,000 cu.ft. of free air is

$$W = 144 \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right] \text{ ft.-lb.,}$$

where $n = 1.41$; P_1 = suction pressure, lb. per sq.in. absolute; P_2 = discharge pressure, lb. per sq.in. absolute, and V_1 = cubic feet of air taken into the cylinder.

If the suction pressure is 12 lb. absolute, the discharge is 100 + 12 = 112 lb. absolute. Substituting,

$$W = 144 \times \frac{1.41}{0.41} \times 12 \times 1{,}000 \left[\left(\frac{112}{12} \right)^{0.29} - 1 \right] = 5{,}414{,}928 \text{ ft.-lb.}$$

If, however, the suction pressure be that of sea level —that is, 14.7 lb. absolute—the 100 lb. gage discharge pressure would be actually 114.7 lb. absolute pressure. Putting these values in the formula,

$$W = 144 \times \frac{1.41}{0.41} \times 14.7 \times 1{,}000 \left[\left(\frac{114.7}{14.7} \right)^{0.29} - 1 \right] = 5{,}927{,}153 \text{ ft.-lb.}$$

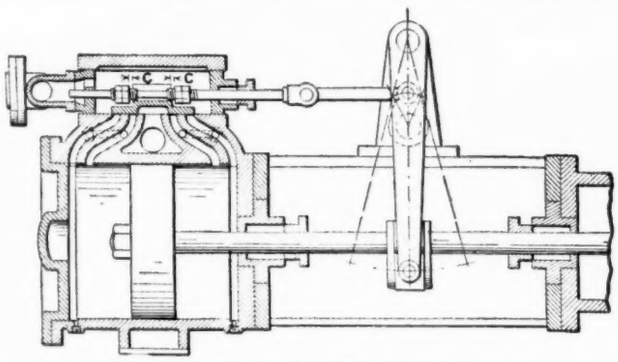
From these calculations it is apparent that at a low suction pressure the power required to raise air through a given pressure increase is less than with a higher suction pressure.

If, however, the absolute discharge pressure is the same—that is, 112 lb. per sq.in.—the work required to compress from 14.7 lb. suction pressure would be 5,838,341 ft.-lb.

Pumps Short Strokes

We have a large duplex steam pump used to pump water from a river for factory purposes. This pump has never worked satisfactorily and always short-strokes. What can be done? J. E. S.

The valve of one side of the pump is moved by the piston rod of the second cylinder. If steam was admitted to this second cylinder, the motion of its piston rod would cause the valve of No. 1 cylinder to open, causing No. 1 piston to move. This will cause the valve of No. 2 piston to move over the steam port and so stop the admission of steam to No. 2 cylinder, the piston of which would then stop. The result would be very short, if any, strokes in both cylinders. To



Clearance of valve-rod nuts

avoid this, the nuts holding the valve to the valve rod are backed off an amount shown as C in the illustration. As a result No. 2 piston can move almost to the end of the stroke before the clearance C on the valve of No. 1 cylinder is taken up and the valve opened. It is necessary to have this clearance, the amount of which depends on the type of pump, etc.

Groaning Steam Valves

If the valves of an engine groan, what may be the cause? R. S.

If the valve on a Corliss or slide-valve engine groans, it is certain evidence that the lubrication is bad. Even though ample oil is being fed, it may not be getting to the valves, but may be settling in a pocket. The valve surfaces should show a film of oil; if not, the seat will cut rapidly.

Refractories Service Conditions in Boiler Furnaces*

By Ralph A. Sherman†

THE trend of design and operation of boiler furnaces is toward larger furnaces, higher ratings, the use of preheated air and the lowering of excess air, with consequent higher temperatures, and the use of lower grades

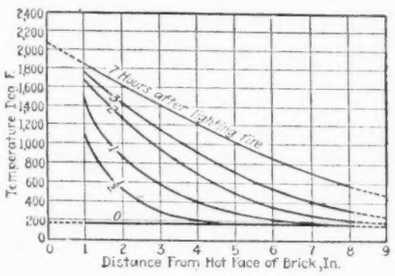


Fig. 1—Temperature gradients in a 9-in. header brick in a 13½-in. side wall of a powdered-coal-fired furnace, at various intervals after lighting the burners in a cold furnace

These curves show a steep temperature gradient on the hot side of the wall for some time after firing. The curve gradually straightens out, but even 7 hours after firing more heat is entering the wall than is leaving, as is shown by the departure from a straight line.

of fuel, all of these factors rendering refractories service conditions more severe.

Early in 1924 a group of large operating companies requested the Bureau of Mines to attack the problem of their boiler-furnace maintenance, and the work is now sponsored by a committee on refractories of the A.S.M.E.

In accordance with the usual policy of the Bureau of Mines the work is being carried on extensively in the field as well as in the laboratory in order that laboratory and service results may be correlated. The problem is so complex that the surface is barely scratched after the work of a year and a half.

Manufacturing and Service Conditions

A first-grade firebrick is the object of the utmost attention and care. The men engaged in the manufacture of firebrick see that this is so. The clays are carefully picked, ground, mixed, tempered, dried and burned according to a predetermined time-temperature schedule, correspondingly carefully cooled, stored in a dry place and packed for shipment to avoid abrasion and breakage.

*Abstract of paper presented at a meeting of the American Refractories Institute, New York City, October 29, 1925 (with the permission of the Director, United States Bureau of Mines).

†Assistant physicist, Pittsburgh Experiment Station, United States Bureau of Mines.

When it becomes a part of the furnace wall or arch, the brick is exposed to the radiant heat of the fuel bed or flames; the surface, at least, reaches a temperature higher than that to which it was fired in the kiln; it is swept by hot gases carrying molten ash from the coal; it is loaded by the weight of the bricks above and subjected to the forces resulting from the thermal expansion of the adjacent bricks; and various changes in the boiler load may subject it to sudden temperature changes.

A firebrick may radically change its characteristics when subjected to these changes in conditions. For example, a brick may have a structure that will not withstand sudden temperature changes and will spall, but on prolonged heat treatment in a boiler furnace its structure may be changed to one that will not spall. It is also frequently the case that the opposite effect is produced.

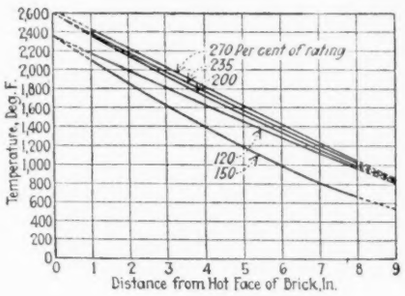


Fig. 2—Temperature gradients in the same wall as in Fig. 1, with the boiler operated at various ratings

The maximum rating shown is 270 per cent, and at this rating the temperature on the hot face is about 2,600 deg. The temperature gradient is about 200 deg. per inch.

The properties of a material such as a firebrick are dependent on the relative proportions of the various minerals present, and the proportion of the minerals may change under heat treatment. This may explain the frequent lack of accord between laboratory test results and actual service trials.

Furnace and Refractories Temperatures

It is recognized that the primary requisite of refractories is that they withstand high temperatures. Just what these temperatures may be for various types of service has rarely been accurately determined.

The term furnace temperature has been too frequently and too loosely used, for there is no one true temperature in a boiler furnace. The temperatures of the fuel bed and of the gases vary from point to point and from minute to minute.

The mean temperature in a boiler furnace depends upon:

1. The calorific value of the fuel.
2. The heat capacity of the products of combustion.
3. The rate of heat absorption from the furnace.
4. The rate of combustion.

If these factors are known, it is possible to calculate a mean furnace temperature, but the result is often in error owing to the lack of definite information on the value of some of the coefficients in the formula. Even if it could be exactly calculated, such a temperature would be of little value in relation to refractories service. It will naturally be lower than the maximum temperature. For example, the mean temperature might be calculated to be but 2,200 deg. F., which should not give severe service, but there might be a localized zone near the wall or arch with a temperature of 3,000 deg. in which area the service would be very severe. On the other hand a temperature of 3,000 deg. in a powdered-coal furnace might be of no consequence to the refractories if this part of the flame were screened from radiating to the wall by an outer and cooler flame.

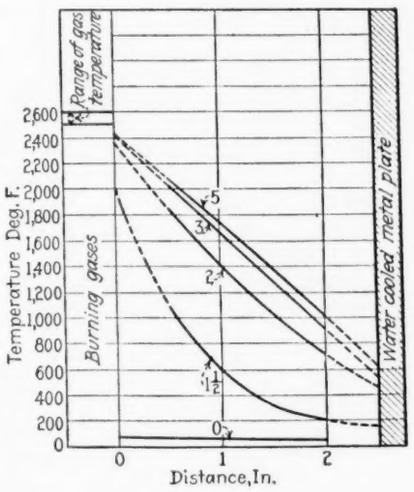


Fig. 3—Temperature gradients through a brick laid flat against the metal of a water-cooled box in which powdered coal was burned

The figures on the curves refer to the time from lighting the burners. These curves show a steep temperature gradient and also the closeness of the inner brick temperature to the gas temperature.

The temperatures that are important in relation to the refractories are those of the flame or fuel bed which determine the refractories temperature or from which slag is being deposited on the wall. Such temperatures can be

determined only by actual measurement.

Temperature measurements in the gases in an underfeed stoker-fired furnace under a 625-hp. boiler operating at 200 per cent of rating showed a maximum of about 2,750 deg. F. along the front wall. Normally, the gas temperatures in other parts of the furnace did not exceed 2,500 deg. The temperatures reached at the surface of 9-in. bricks placed in the front wall and side

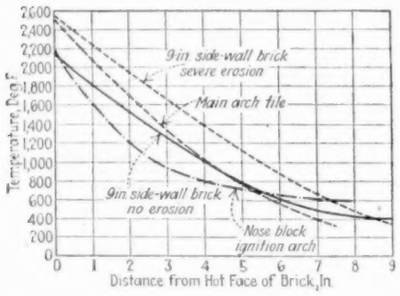


Fig. 4—Temperature gradients at four places in a chain-grate stoker fired furnace, 15 hours after lighting the fire

The temperatures on the face of tile in the main arch and of the 9-in. brick in the side wall, which showed severe erosion, were between 2,500 and 2,600 deg. The temperatures on the face of the nose block in the ignition arch and of the 9-in. brick which showed little erosion were between 2,100 and 2,200 deg.

wall directly over the fuel bed were 2,400 and 2,300 deg. respectively. The maximum temperatures found in the small powdered-coal furnaces investigated by the Bureau of Mines at Milwaukee some years ago were about 2,700 deg. In other powdered-coal furnaces we have found instances of 2,800 degrees.

[Figs. 1 to 4 show the temperatures at various points within the brick, and the slope of the curves indicates the change in temperature, which is known as the temperature gradient, in degrees per inch. During the warming-up period, heat enters the brick on the fire side faster than it escapes to the outside, and the gradient is therefore greater at the fire side. When a steady state is reached, the heat entering a brick is all transmitted through and out to the surroundings, and hence the gradient must be constant, or in other words, the temperature curve must be a straight line. The figures show that the process of warming to a steady state requires several hours after the fire is started.—Editor.]

The gas temperatures in the furnace of Fig. 4 ranged from occasional readings of 2,900 to 3,000 deg. directly over the fuel bed to 2,000 deg. in the front and rear of the stoker. The gases at the nose of the main arch were normally at 2,500 or 2,600 deg., while the maximum temperature reached on the surface of the blocks during the period in which temperatures were measured was from 2,600 to 2,700 deg. The temperature on the face of the bridge wall, as determined by thermocouples and the optical pyrometer, was from 2,500 to 2,550 deg. The temperature of the gases passing over the bridge wall was only 2,000 to 2,200 deg. The fact that the temperatures of the arch and the bridge wall were as high as or higher than that of the gases passing over them, shows that the temperature of the fuel bed radiating to them was the determining factor in their temperatures.

The temperature of the gases immediately inside the walls is usually several hundred degrees lower than the main stream of gas owing to stratification of streams of air coming in through openings in the wall. If this stream is not opaque to radiation, the temperature of the walls will approach that of the main stream or of the fuel bed.

The temperatures that have been cited were not read in the largest furnaces operating, but they were taken under fairly high boiler ratings and represent an average severity of service. Since these temperatures are not high, 2,500 to 2,700 deg., and since it is possible to secure refractories and cements guaranteed to stand up under temperatures of 3,200 deg., it would seem that there should be no serious refractory problem under these conditions.

It is obvious that the refractories shown in Fig. 5 failed in a very short time. The fusion temperatures of these refractories have not been determined but, being first-grade brick, were doubtless over 3,000 deg. Since the temperatures reached were considerably lower than this, the refractories did not fail because of fusion. In none of the 34 plants visited during the course of this investigation was there seen an instance of failure because of fusion alone. If there were no slag or no changes in temperature in boiler furnaces, the guarantees might stand good, but unfortunately boiler furnaces are not operating under these conditions.

The results of these experimental determinations of refractories temperatures have confirmed the impression previously held, namely, that refractories with higher fusion points are not needed for boiler-furnace service. Super-refractories, super-, not in resistance to high temperature, but super- in resistance to slag action and spalling, are sorely needed.

Slags and Refractories

Coal ashes resemble refractory clays in composition, but contain high percentages of fluxes such as iron, alkaline earths and alkalies. The softening temperatures range from 3,000 deg. for a few Eastern bituminous coals to 2,000 deg. for coals such as those from the Illinois fields.

It has been seen that the temperatures in boiler furnaces usually exceed 2,500 deg. Therefore most ash melts and forms a slag. If this slag is carried by the gases and strikes the wall which is at a like temperature, a combination takes place and a new slag is formed whose softening temperature may be even lower than that of the coal ash or the refractory. The subsequent action depends on the viscosity of this slag under the existing furnace conditions. Since the slags contain iron, the furnace atmosphere will have a bearing on the viscosity, oxidizing gases favoring the formation of ferric silicates, which have a higher softening temperature than the ferrous silicates which are favored under reducing conditions.

The composition of the slag deposited on the refractory may not, and probably will not, be the same as that of the coal ash. The ash is not homo-

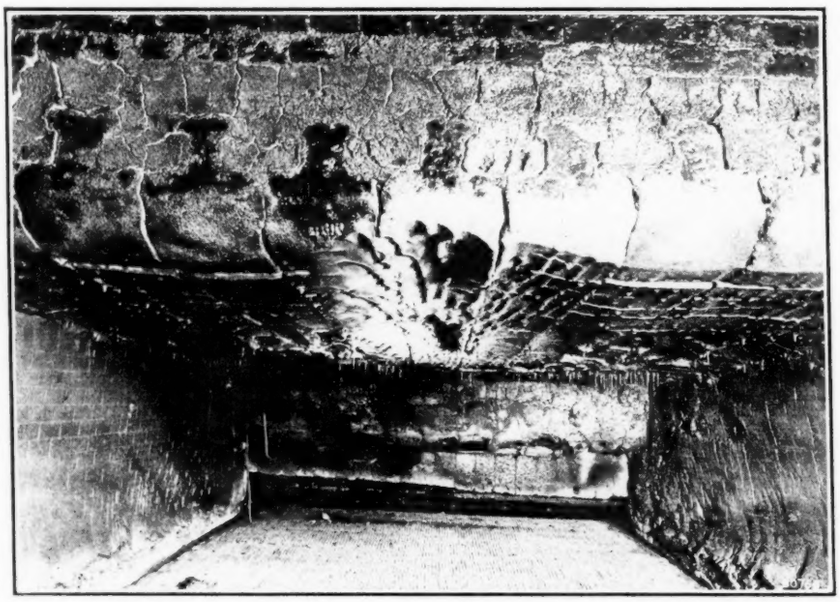


Fig. 5—What happened in a boiler furnace fired with a chain-grate stoker under the temperature conditions of Fig. 4

The right side wall of this furnace had seen at this time about three months' service and was almost ready for replacement. The left side wall had been in service only two weeks and the maximum erosion was about an inch. The tile in the center of the arch which are so deeply grooved were placed new two weeks before the photograph was taken. The temperatures at the surface of these blocks was only from 2,500 to 2,600 deg.

geneous, and there is probably a selective action between that which remains in the fuel bed and that which is carried in the gas stream. The comparison of the composition of the slag deposited on the boiler tubes with that of the coal ash in one case showed that the slag contained a considerably higher percentage of iron than did the coal ash.

Eastern Bituminous Coals Give High-Viscosity Slags

The Eastern bituminous coals ordinarily give slags of high viscosity which adhere to the refractory and build out, giving the familiar phenomenon of slag adhesion. This is injurious to the wall, as it must be broken off and the bricks are often broken with it. The action of these highly viscous slags is not, however, nearly as severe as that of the slags from the Illinois coals, which are so fluid that they drip off, flow down the wall or are carried away in the gas stream. They dissolve the refractory in the same manner that a stream of water will dissolve a block of sugar.

If the molten ash could be prevented from striking the walls, the erosion would be prevented. One of the principal reasons why it is often difficult to operate powdered-coal furnaces without slagging is that all the ash is carried in the gases, while in a stoker-fired furnace a large percentage remains on the grate.

Of several types of powdered-coal burners that have been investigated in one furnace, it was found that one in particular had the zone of maximum intensity of combustion and hence the highest temperatures very near the burners, while with another type this zone was located at some distance from the burners and at a point where the flame changed direction. In the first type the gases and slag were so cooled by the time they reached the refractories that little difficulty was experienced with slagging, while with the latter type the slag was thrown out of the flame onto the refractories in a very fluid condition and it was difficult to operate at high ratings and low excess air without serious slagging.

Use of Slag Screens

Water-cooled heat-absorbing surface was introduced in the form of slag screens in the bottom of powdered-coal furnaces to lower the temperature of the slag and increase its viscosity so that it would not erode the bricks and could easily be removed from the furnace. The use of such heat-absorbing surface has been extended to the use of side-wall heating surface and radiant superheaters and is now to be tried in the main fire arch over chain-grate stokers. This heating surface may be exposed directly to the flame, eliminating the refractory in this area, or it may be covered with a thin tile. The effect of this surface is to lower the temperature in all parts exposed to it and thus the mean temperature of the furnace, but it does not necessarily follow that the temperature and the severity of service are lowered in all parts of the flame. An opaque flame may shield a very high temperature zone from radiating to the cooling surface. If this zone is near the refractory, the severity of service in this area will not be lessened.

Spalling

It is impossible to say as much about spalling as its seriousness warrants because so little is known about it. In Fig. 5 there is evidence of spalling on the main arch. Most of this spalling seems to start by breaking off of the corners of the arch tile. It is quite evident that spalling is more severe on large pieces such as these blocks than it is on 9-in. bricks. Whether this is a function of size alone or is connected with the method of manufacture cannot be said definitely, but probably both factors affect spalling.

Conclusion

The principal points that it has been desired to bring out are:

1. That a brick may radically change its characteristics under service conditions.

2. That furnace temperatures cannot be calculated, but must be experimentally determined.

3. That the composition of the slags may be different from that of the coal ash.

4. That the introduction of a limited area of heat-absorbing surface in a furnace will not necessarily lessen the severity of action in all other parts of the furnace.

5. That refractories do not fail by fusion. Manufacturers should not attempt to sell nor should users buy refractories merely on the basis of their fusion points.

The aim of this investigation is to lower the cost of boiler-furnace maintenance. The ultimate solution of the problem is not yet in sight. It is felt, however, that to a large degree the solution lies in furnace design to avoid the deposition of ash on the surfaces, the introduction of air to deflect gases, and the introduction of water cooling. For the very severe service the latter method or a refractory is needed with increased resistance to slagging and spalling. The introduction of heat-absorbing surface is not a general solution, for there are hundreds of plants in operation and to be built in which it could not be adopted. These plants have serious refractory problems and they must be met.

Joint Feed-Water Studies Now Under Way

A report just released gives the final organization of personnel and subject matter of the boiler-feed water investigation inaugurated a little over a year ago and now being carried on under the auspices of the American Water Works Association, the A.S.M.E., the American Railway Engineers Association and the N.E.L.A. The American Society for Testing Materials has also been invited to join in the work.

The studies are to include the causes and prevention of corrosion of ferrous and non-ferrous materials used in steam-station practice, and related problems in railroad and central-station practice.

There is an Advisory Committee and nine subcommittees, each of which is selecting data relative to the subject assigned to it and will compile yearly reports.

The subjects to be investigated by the committees are as follows:

Subcommittee No. 1—Sedimentation with and without chemicals, pressure and gravity filters and deconcentrators, continuous blowdown apparatus.

Subcommittee No. 2—Water softened by chemicals (external treatment). This study will consider the chemical reactions in the light of present knowledge of physical chemistry. It will compile operating data to determine the relative value of continuous and intermittent softeners. It will also study the standardization of filtration rates, the economic value of lime-soda softening preliminary to zeolite softeners or evaporators.

Subcommittee No. 3—Zeolite softeners, internal treatment, priming and foaming, electrolytic scale prevention. The committee will make an unbiased study to determine the specific fields of usefulness of zeolite softeners and boiler compounds. It plans pioneer work in connection with a study of the electrolytic method of scale prevention and hopes to remove some of the confusion now existing as to the causes and prevention of priming and foaming.

Subcommittee No. 4—Surface condensers, evaporators and deaërators. The use of lime-soda treatment in connection with evaporators will be studied among other things.

Subcommittee No. 5—Corrosion of boilers and the effect of treated water in accelerating or relieving these troubles.

Subcommittee No. 6—Embrittlement of metals.

Subcommittee No. 7—Municipal water supply in relation to boiler use.

Subcommittee No. 8—Standardization of water analysis.

Subcommittee No. 9—Bibliography. This committee is to abstract current articles of interest. A complete bibliography of boiler feed-water methods and allied problems may later be attempted.

In a recent report on the water-power resources of the Taylor River, a tributary of the Gunnison River in Colorado, prepared by E. E. Jones, a hydraulic engineer of the Geological Survey, a plan is presented by which Taylor Park Reservoir could be used to equalize the flow of the river for generating power and at the same time increase the supply of water for irrigation late in the season so as to insure a sufficient supply except perhaps in an unusually dry year. Even without a reservoir, by constructing low dams and conduits the unregulated flow of the river could be used to generate 17,000 hp. for 50 per cent of the time and 10,000 hp. for 90 per cent of the time. If the flow should be regulated by a reservoir at Taylor Park, 33,000 hp. could be generated for 50 per cent of the time and 31,000 hp. for 90 per cent of the time. A copy of the report may be examined at the office of the Survey in Washington or at the Denver office of the Survey at 403 Federal Building.

Waste-Heat Boilers

Relative Adaptability of Water-tube and Fire-tube Types

AT A joint meeting of the Chicago Section of the American Society of Mechanical Engineers and the Mechanical Section of the Western Society of Engineers, on Nov. 16, 1925, F. H. Willcox and J. C. Hayes, of the Freyn Engineering Co., Chicago, presented a paper on "Waste Heat Boilers in Steel Mills."

They pointed out that in a waste-heat boiler utilizing gas at 1,200 deg. F., direct radiation is less than one-tenth of that in a direct-fired boiler. Rapid water circulation, therefore, is not a prime requisite, but for maximum heat recovery through intimate contact between gas and heating surface there must be a positive scrubbing action produced by close tube spacing in a water-tube boiler or by the use of small tubes in a fire-tube boiler. It is usually necessary to install an induced-draft fan.

In proportioning waste-heat boilers, the two most important requisites are a high rate of heat transfer and a low draft loss. Between these contradictory requirements a compromise is necessary.

Water-Tube versus Fire-Tube Boilers

Water-tube boilers have been successfully operated with gases from forge furnaces at temperatures exceeding 1,800 deg. F. This is at least in part due to the transmission of heat by radiation. For waste-heat recovery from gases at 1,200 deg. F. on the other hand, water-fube boilers have given discouraging results.

Early experiments with water-tube waste-heat boilers for low-temperature gases showed that much closer tube spacing was necessary than for direct-fired boilers. This led to higher draft losses and higher power consumption for the induced-draft fan. Difficulties in cleaning the heating surface and with air infiltration were serious drawbacks to the use of the water-tube boiler, but these troubles have been reduced through the use of soot blowers and hand lances and by the use of monolithic baffling and steel casings. In waste-heat practice there is no special advantage for either type of water-tube boiler because the cross-baffling, which gives better heat transfer, involves larger draft loss.

Gas Flow and Dust Removal

Draft should pass through the boiler with the least possible number of changes in direction of flow. The ideal path is that offered by a continuous tube, and the smaller its diameter the closer will the gas be to the heating surface and the better will be the heat transfer. A suitable design of fire-tube boiler setting will allow no short-circuiting of gas or any bypassing of heating surface through dead pockets in the gas.

To obtain the maximum economy with a waste-heat boiler, it is essential that the heating surface be kept clean. It is easier to do this on the gas side with a fire-tube boiler than with a water-tube boiler. A simple hand lancing arrangement is effective in cleaning the interior of fire tubes. On the other hand, the water side of the heating surface is more readily cleaned in a water-tube boiler, and when a fire-tube boiler is used, the proper treatment of boiler-feed water should be assured. In this connection the authors pointed out that the slow and steady rate of evaporation in a waste-heat boiler makes it possible to permit a higher content of solid matter in solution in the boiler-feed water.

Space and First Cost

A fire-tube boiler requires less space than a water-tube boiler of the same heating surface and, for the same output, the fire-tube boiler requires less heating surface. In consequence, the fire-tube boiler installation is usually much less costly. Experience has shown that tube-sheet leakage in a waste-heat boiler is not a serious factor. The flow of gases is seldom over a wide range in temperature, and there is no occasion to open firing doors or otherwise admit cold air to the tube sheets.

Much of the prejudice against the use of the fire-tube boiler is based on the failure of this type to compare favorably with water-tube boilers in high-pressure stationary service, but many of the factors contributing to this do not apply in waste-heat practice. For example, the waste-heat boiler does not have to absorb radiant heat, and it is not necessary to pass the hot gas across the lower half of the shell as is common in the horizontal return-tubular setting, nor to install fireboxes, water legs or other expensive stayed surfaces. No brick setting is required for waste-heat boilers, so that cold air infiltration and heat loss by radiation may be practically eliminated.

Induced Draft Fan Energy

The energy used for driving the induced-draft fan should not exceed 5 per cent of the boiler output, and in cases where regenerators are not used, it should not exceed 3 per cent. When regenerators are used, the reversing damper should not be water-cooled. This permits the gases to reach the superheater at the highest possible temperature.

The accompanying table gives test data on a fire-tube boiler at the plant of the National Malleable & Steel Casting Co., at Melrose Park, Ill. In this instance 38 per cent of the heating value of the furnace fuel was recovered in the form of steam. In addition to this there has been marked improvement in the performance of the open-hearth furnace due to the better draft available.

Auxiliary Furnaces

Sometimes there is a demand for an auxiliary furnace to fire the boiler directly if it is needed when the furnace is out of service. The superheater must be protected against excessive temperature, but the boiler is otherwise operated in the same manner as on waste heat. Auxiliary furnaces must be designed to insure complete combustion before the products reach the heating surface. Furnace volume and flame travel must be adequate.

In addition to steel mills cement kilns offer possibilities for waste-heat recovery. In these the volume of gas is reasonably constant and the temperature runs close to 1,100 deg. F. Interest is also being revived in the recovering of waste heat from the exhaust of gases from large internal-combustion engines. By this means the heat lost in the hot exhaust gases, which is normally about one-third of the heating value of the fuel, may be reduced to approximately 10 per cent.

In discussion it was pointed out that it is a mistake to blow dust from a waste-heat water-tube boiler too frequently. If the first pass is blown every 24 hours and the other passes are never blown, the operation will be just as efficient as with an 8-hour blowing interval throughout. The reason is that dust will pyramid on top of the tubes and will collect within a half-hour after blowing.

It was suggested in connection with cement installations that the use of a common flue between the kilns and the boilers enables them to be operated independently. In most plants it has been found that sufficient waste heat can be recovered to run the entire cement mill. A number of cement companies are able to sell power to near-by towns as a by-product of their waste-heat system.

TEST OF WASTE HEAT BOILER

Duration of test, hr.	7	8.25	8.75
Steam pressure, lb. gage	140.9	140.0	133.8
Temperatures, deg. F.:			
Gas before superheater	1,348	1,338	1,331
Gas before fan	485	490	478
Steam after superheater	495	473	484
Feed water	175	187	184
Drafts, in. of water:			
Before superheater	0.63	0.64	0.64
Before boiler (after superheater)	0.91	0.91	0.91
Before fan (after boiler)	3.20	3.19	3.20
Base of stack (after fan)	0.84	0.87	0.85
Evaporation:			
Total, lb.	53,485	65,169	75,095
Average, lb. per hr.	7,641	7,899	8,582
Average CO_2 in waste gases per cent by volume	9.06	8.71	8.55
Average oil consumed, gal. per hr.	152.7	155.2	160.5
Fan speed, r.p.m.	644	651	645
Boiler horsepower developed:			
Total	258.0	261.8	286.5
Superheater	16.7	14.6	17.6
Boiler	241.3	247.2	268.9
Temperature of saturated steam, deg. F.	361	361	357.5
Superheat, deg. F.	134	112	126.5
Weight of waste gases, lb. per hr.	38,500	39,800	43,200
Input to fan motor, b.hp.	18.1	18.9	19.5
Rating of boiler, per cent	102.5	105.0	114.5

Instruments for the Refrigerating Plant*

By John A. Hawkins

OF FIRST importance as an instrument for refrigeration or temperature control is the thermometer. There are a number of different types and grades of this instrument, and careful consideration should be used in selecting those best suited for the service to be performed. Two general classes are to be had, indicating and recording, the former registering the temperature at the time the reading is taken, while the recording type gives a graphic chart, usually for twenty-four hours, of the prevailing temperature over that period. The question of which type to install depends entirely on individual plant conditions or requirements.

All thermometers should be accurate and graduated through the desired range in a manner that will allow accurate readings to be taken. Also they should be strong and rugged in construction for long life.

Location of Thermometers

Thermometers should be installed permanently at the inlet and outlet of every piece of equipment where there is a heat exchange, so that the operator may know definitely what the equipment is doing. The frost line or feeling with the hand are at best poor guesses.

Next of importance are instruments for reading pressures. These may be the ordinary indicating pressure gage or a recording instrument. Pressure gages require testing with a dead-weight outfit at least once a year and oftener if any inaccuracy is discovered.

For pressure readings that are comparatively low, a mercury tube should be used. A pressure gage of this type is easily read in tenths of a pound and is desirable when installed on the evaporating side of an ammonia compression plant.

If it is desired to check the liquid off temperature with the head pressure, a gage should be installed directly on the condenser. Otherwise the pressure drop between the compressor and the condenser will cause confusion in making this check.

An Indicator Is Necessary

Cylinder pressure indicators, or engine indicators as they commonly are called, are used together with thermometers to diagnose compressor ailments and maintain compressor efficiencies. Unlike on a steam cylinder care should be used to connect the indicator as close as possible to the cylinder end and one end only should be taken at a time. This is to avoid an untrue diagram owing to the re-expansion of the trapped gases in the indicator piping.

Just as the pressures and temperatures are important, so also are quantities. To determine the quantity of condensing water pumped there should be a meter or a water weir. Estimating from pump capacities is not accurate, because pumps become worn, the packing may not be in first-class condition or some lines may be tapped off from the discharge of the pump, so that the total capacity does not go over the condenser. Usually, a home-made water weir built on the return line from the condenser will answer this purpose.

Venturi flow meters have proved adaptable to refrigerating work for measuring water, brine and ammonia. For measuring brine, Venturi meters are used successfully to determine refrigerating costs and loads in brine-cooled rooms of warehouses. This type of meter is also a convenient means of measuring the condensing water supply.

Meters Help Operation

The author is impressed particularly with the value of this type of meter when used on the liquid ammonia lines to the various evaporators of the system. With the present-day practice of flooded coils and accumulators for ice tanks, a system of operation can be laid out that will take all the guess from ice-tank work. Without the meter ammonia is fed to these coils to keep them full, with perhaps a slight head of liquid in the suction riser, and also keep the gas dry, but not superheated, to the compressor. A thermometer on the suction riser indicates when the saturation temperature has been reached, that is, the temperature corresponding to the pressure in the coils. It will not tell that the feeding rate is too low until the quantity is reduced to such an extent as to cause the suction gases in the riser to become superheated. Neither will this thermometer show when the feeding rate is too high. The first indication is a drop in temperature of the suction gases to the compressor with the attending danger of liquid slugs.

Establishing a Rate of Flow

Using a Venturi meter, a rate of flow can be established by practice that can be maintained permanently. Actual practice has shown that by the use of such a meter 3 to 5 per cent more liquid ammonia can be evaporated in a given tank. When the rate has been established, the meter becomes a continuous check on the compressor and this evaporator. Neither can lose in capacity without its becoming evident at once, where otherwise it perhaps would go for days without notice. Another advantage of this instrument is that it reveals at once any vapors in the liquid. It is a well-known fact that a liquid seal must be maintained in the receiver to obtain any degree of efficiency. The remedy, of course, is to increase the ammonia charge.

Portable air-flow meters are often used to determine quantities of air delivered through the ducts in a warehouse using air circulation.

Many plants use electric motors to some extent. A portable voltmeter and ammeter may be used to advantage for finding the power input to individual units. These instruments can be recommended especially for use on motors driving conveyors of different types, so that efforts may be made to reduce friction to a minimum through proper lubrication, working tension and general maintenance. Losses such as these have been reduced as much as 40 per cent.

A lamp for testing fuses and finding grounds on electrical circuits is especially useful and will often save time in locating trouble.

The qualities and purities of the different substances used about the plant must be watched. A salometer is an instrument built similar to a hydrometer and graduated to read in per cent salt. When the brine is tested with the salometer, the reading can be checked from tables as to its freezing point. Care should be taken to maintain the strength of the brine. A slight covering of ice on brine coils or tubes will retard the heat transfer to such an extent that the refrigerating capacity will be lowered. Also, it has been proved that a weak sodium chloride brine is much more corrosive than a strong solution.

Testing Ammonia Purchases

Ammonia manufacturers usually encourage the testing of their product and supply test bottles for this purpose. The tube or bottle should hold 100 c.c. and be graduated to a small neck in the bottom in spaces of 1 c.c. Thus if the bottle is filled to the 100 mark and the ammonia allowed to evaporate, any resulting residue will be left in the lower neck. If 2 c.c. will not evaporate, then it is assumed that there is 2 per cent of impurities present. Frequent tests of this kind should be made of the plant charge. The tube should be immersed in a cold brine bath while evaporation is taking place, because if too violent boiling is allowed, some impurities may be driven off with the ammonia vapor, making the test incorrect. The temperature at which the substance boils should be checked at this time. From ammonia tables it will be found that this temperature should be 28 deg. F. Presence of moisture in the ammonia will raise the boiling temperature.

Lubricating Oil

Plants that use 50 gal. or more of lubricating oils each month should be equipped to make simple tests of new oils purchased and also of reclaimed oils from the system. An outfit of this kind need not consist of more than a gas burner, a cup, a few test tubes and two thermometers. One thermometer should be graduated to 400 deg. F. and the other from —30 deg. F. An oil-testing outfit will be of assistance to the engineer in solving lubricating problems and insure the plant against excessive wear of machinery and clogged evaporating coils.

A leaflet issued by the Wilmington, Del., Chamber of Commerce shows that the firm of James E. Rhoads & Son is the oldest concern carrying the family name in America. The Rhoades firm is a manufacturer of leather belting and was started at Marple, Delaware County, Pa., 223 years ago and is still operated by the descendants of the founders. It moved to Wilmington in 1868.

*From a paper read at the sixteenth annual convention of the National Association of Practical Refrigerating Engineers, Detroit, Dec. 8-12, 1925.

News in the Field of Power

Conowingo Project on the Susquehanna Will Be Started in a Month

Mitten Withdraws Objections—Maryland and Pennsylvania Public Service Commissions Approve New Arrangement of Engineering and Finance

THE Philadelphia Electric Co.'s petition for approval of its $52,000,000 hydro project, at Conowingo on the Susquehanna River, was allowed on Jan. 12 by the Pennsylvania Public Service Commission. The Public Service Commission of Maryland has already passed favorably on the project. The permission from the Federal Power Commission will probably be forthcoming shortly.

The Philadelphia Rapid Transit Co., single largest user of the Philadelphia Electric Co. current, had protested certain engineering features of the plan as first proposed and also pointed out that the financial set-up of the Philadelphia Electric's intercorporate bodies was calculated to bring excessive returns to the promoters of the project, with strong possibility of consequent increase in rates to consumers. The P. R. T.'s contentions in the main were upheld by the Public Service Commission of Pennsylvania, which recently issued an order calling upon the Philadelphia Electric Co. to submit a revised application with the undesirable features of the project eliminated. The Philadelphia Electric Co. shortly thereafter complied with the commission's ruling.

T. E. Mitten, chairman of the board of directors of the P. R. T. Co. in a letter, stated that, inasmuch as the revisions made in the petitions complied and dispensed with the objections of the protestant company to the Conowingo project, the objections were formally withdrawn.

A part of the Commission's statement on the Conowingo reads:

"Approval of the Conowingo project by the Commission was upon the conditions prescribed in the Commission's Interim Report of Dec. 1, 1925. These conditions, which placed the rate of return for the project upon the basis of 7 per cent of investment cost, eliminated the so-called coal clause, eliminated the issuance of bonus stock and made other provisions which the Commission stipulated should be made in the public interest, were agreed to by the Philadelphia Electric Co. and its subsidiaries in the Conowingo project."

According to the press, Stone & Webster, of Boston, have estimated that the plant can be completed in two years and nine months.

It is also reported that the Susquehanna Power Co. will build and own the property in Maryland; the Susquehanna Electric Co. will operate the plant; the Susquehanna Water & Power Co. will own the transmission lines and other property in Pennsylvania; all these companies will be controlled by the Philadelphia Electric Co., organized by the Drexel & Co., Philadelphia bankers, who are hadling the financing of the development.

According to reports in the press, a contract has been let by Stone & Webster, of Boston, who was awarded the original contract, to the Arundel Corp., of Baltimore, to begin construction in a month on the plant. The report also states that the Arundel Corp. will excavate and build the dam, the price being upward of $20,000,000.

Balch Hydro Plant To Have Very High Head

A station now under construction on Kings River in central California is to operate under an ultimate static head of 2,470 ft.—nearly half a mile. It will be the highest-head hydro-electric plant in America. The San Joaquin Light & Power Corp. expects to have the station in operation within a year.

It is to be named the Balch plant in honor of A. C. Balch, one of the pioneers of the San Joaquin corporation. The entire Kings River project will involve the expenditure of $50,000,000. Thus far approximately $1,500,000 and five years' time have been spent in preliminary surveys, in road building and in erecting a power line to supply the construction camps with electricity. The Balch plant is noteworthy not only because of the head at which it will operate, but because ultimately it will contain four of the largest horizontal waterwheel generators in the country. The first of these units, rated at 33,000-kva. 13,200 volts, is being made by the General Electric Company.

A dam with a height of 65 ft. and a length of 190 ft. at the crest is now under construction at Williams Crossing and, when completed, will form a 200-acre-foot surge pond. As the demand for power increases and other power plants are necessitated, it is planned to absorb this dam in a larger dam to be built on the same site. This larger dam will be either a rockfill or a multiple arch structure 175 ft. high, with a crest 800 ft. long. The elevation of the crest of the diversion dam will be 4,065 ft., which will provide an initial effective head of 2,280 ft. and a static head of 2,355 ft. The ultimate structure will raise the elevation of the spillway to 4,180 ft., increase the heads to 2,312 and 2,470 ft., respectively, and create a 5,000 acre-foot surge basin. Storage sites farther up in the mountains provide the possibility of future storage developments to the extent of 230,500 acre-feet.

It is planned to carry the water from the diversion dam at Williams Crossing to the penstock, a distance of over three miles (19,500 ft.), in a tunnel cut through soiid granite. This tunnel, 12 x 12 ft. in cross-section, will carry 720 sec.-ft. of water at a slope of 3.3 ft. per thousand feet of length.

Steel penstocks, of about 4,700 ft. slope length, will connect the tunnel exit at an elevation of 3,966 ft., with the nozzles at an elevation of 1,710 ft. The abruptness of the descent is evident from these figures. The upper 3,500 ft. of penstock will be a single pipe, while the balance will be split into two pipes because of the pressures encountered. One penstock complete will weigh approximately 1,664 tons.

An unusual condition is encountered at the power-house site. There is no place immediately at the foot of the penstocks large enough to accommodate the power house, while across the river there is plenty of room. This resulted in incorporating several peculiar features in the plans. The penstocks will be carried across the bed of the stream in heavy, reinforced-concrete anchorages, and with the water entering the plant from the river side, the tailrace will be constructed in such a way that it will dispose of the water without any back-washing effect.

Louisville To Use Air Coolers With Hydro Generators

The first use of fin type surface air coolers with hydro-electric generators will be made in connection with the new station that is being built by the Louisville Hydro-Electric Co., just above Louisville, Ky., on the Ohio River. Because of the use of soft coal in the city and the consequent trouble that would be caused if open ventilation of equipment was used, it has been decided that the closed system of ventilation would be preferable. The major use of surface air coolers has been with turbine-generator equipments.

The generating equipment of the new station will include eight 10,000-kva. 14,000-volt 100-r.p.m. hydro-electric generators, each equipped with fin-type surface air coolers. Both the generators and coolers will be supplied by the General Electric Company.

The development is being made at the site of one of the state-built navigation dams. According to the season the head varies to a maximum of 40 ft. The power developed there will be used in and around Louisville.

General Electric Denies Power Monopoly

The General Electric Co., in a letter to its stockholders, just made public, denied that it controls the water, power and light industries of the country; that it is a great monopolistic interest or gigantic trust, and that it is controlled by J. P. Morgan & Co.

The letter, signed by Owen D. Young, chairman of the board of directors, and Gerard Swope, president, is in reply to certain moves made against the company in Congress and the first time in this way defines the company's policy.

The Senate on Feb. 9, 1925, directed the Federal Trade Commission to investigate and report to the Senate to what extent the General Electric Co. monopolizes or controls the production, generation or transmission of electric energy in restraint of trade or commerce and in violation of the law.

Savannah River To Be Developed

Plans for a large water-power development, including the building of a dam across the Savannah River at Modoc, S. C., have been announced. The application for a preliminary permit covering the project has been filed by the Twin City Power Co., of Parksville, S. C., and the Twin City Power Co., of Augusta, Ga., with the Federal Power Commission. Public hearings will be held in Augusta, Ga., on Jan. 27, before Major William F. Tompkins, district engineer, representing the Federal Power Commission.

The project contemplates the construction of a dam two miles east of Modoc, S. C., to develop a head of 100 ft.; a pool 25 miles long will be created. This is reported as being one of the most important projects ever contemplated in Georgia.

Buenos Aires Steam Station To Have Two Large Turbines

After an exhaustive engineering study which included inspection of the most modern power developments in both Europe and America, the Compania Hispano-Americana de Electricidad is obtaining two 52,500-kw. tandem-compound steam turbine generators as the initial installation for the new generating station to be built at the entrance of the harbor of Buenos Aires.

Each generator will be a 50,000-kw., 13,200-volt, 1,500-r.p.m., main unit with a 250-volt, direct-current exciter, and a 2,500-kw., 2,300-volt service generator with its own direct-current exciter, all mounted on the same shaft. The turbines will operate at an initial steam pressure of 550 lb. gage and 750 deg. F. total temperature, with full intermediate heat of the steam between the cylinders. This is the first time that these steam conditions have been used in so large a commercial station outside the United States.

The units, which will be supplied by the International General Electric Co., are the largest ever built for export. They are designed for exceptionally economical fuel consumption.

Pennsylvania Legislators Now Considering Remedial Laws for Handling Anthracite Coal

Operators and Miners End Conference—Governor Pinchot Advocates Considering Anthracite a Public Utility—Other Bills Cover Repeal of Tonnage Tax and Changes in Miners Certificate Law—Hammond Would Have I. C. C. Find Out Facts

THE COMMITTEES of anthracite operators and miners which had been in conference for eleven days at the Union League Club, New York City, broke off their strike settlement negotiations on Jan. 12. Their action dispelled the last hope for an early return to work of 158,000 hard coal miners, and a resumption of coal production which would have brought relief to the whole Eastern section of the country.

With representatives of employers and the union in their increasingly bitter frame of mind and hopelessly deadlocked on arbitration, it was generally agreed that the destructive industrial war, now in its fifth month, could be brought to an end only by the interference of some outside agency. Official Washington is being spoken of in this connection, although all such intentions have been officially denied.

Pennsylvania Legislature to Consider Anthracite a Public Utility

A bill to declare anthracite a public utility was offered to the special session of the Pennsylvania Legislature, which convened at Harrisburg on Jan. 13, at the call of Governor Pinchot.

"I shall do my best to press the bill which recognizes anthracite as a public utility," declared the Governor in discussing his bills.

The first bill amends the public service law by inserting the phrase "anthracite producers" in the category of businesses that fall within the jurisdiction of the public service commission. Furthermore, it defines anthracite producers as including "all persons, partnerships, unincorporated associations or corporations engaged in the production, preparation and making ready for market of anthracite coal for domestic uses and in the sale of such coal."

The bill would make it possible for the Public Service Commission to inquire into anthracite production, for the public to attack the rates charged by the operators and would generally provide for a public scrutiny of the anthracite business that has not hitherto been possible.

The second bill, aimed at the retailers, "requests" the Governor to negotiate compacts with anthracite consuming states providing for the regulation of the retail features of the anthracite trade. This bill declares the anthracite business as "affected with a public interest" and provides that every compact so entered into shall be submitted to the General Assembly for ratification.

The approval of the General Assembly would in effect make the compact a law. Like all other Interstate compacts, consent of Congress is required to make the compacts valid.

Senator Patrick F. Joyce, Luzerne County, sponsored the bill for repealing the anthractie tonnage tax. Similar bills have been supported in past sessions by operators and miners alike.

"It is the opinion of the Legislature," states the preamble to the bill, which is brief and merely repeals the Tax act of 1921, "that the existing tax on anthracite coal and its consequent effect on the price thereof to the public is one of the chief elements entering into the continuation and prolongation of the strike, and that the repeal of the said tax would hasten the end thereof."

Still another bill aimed at the periodical strikes in the anthracite district was offered by Senator George Woodward of Philadelphia. It makes radical changes in the miners' certificate law, which has been on the statutes of Pennsylvania since 1889. Two years' experience as a practical miner is required before applicants are permitted to take an examination for a certificate under the existing law. The offered amendment would remove this restriction and would provide for the issuance of a certificate by a district examining board to miners who appear before the board and answer "intelligently and correctly at least twelve questions in the English language pertaining to the requirements of a practical miner."

Hammond Advocates Coal Commission's Recommendation

According to the *Christian Science Monitor*, John Hays Hammond, formerly chairman of the United States Coal Commission by appointment of President Harding, said in an interview that, in his opinion, there is valid ground for the miners' unwillingness to submit their disputes with the operators to arbitration, and as a substitute for arbitration recommended mediation by jointly appointed conciliation boards, both local and national. He said he favored voluntary arbitration whenever it could be agreed upon, but he did not approve compulsory arbitration.

Asked how these recommendations could be applied to end the present deadlock and provide for continuous operation of the mines, Mr. Hammond said that in the present situation his recommendation was the same as that of the Coal Commission of which he was chairman, made in 1923; namely, the establishment of a coal division of the Interstate Commerce Commission, to serve as a continuous fact-finding and publicity agency, authorized to make special compulsory investigations whenever, as at present, there was a threat of failure to renew a wage agreement, with possible resort to mediation at the instance of the President of the United States, the coal division itself to act in emergency as

federal fuel distributor. Continuing, Mr. Hammond said this was a time when the recommendations of the Coal Commission, in their entirety, made after an exhaustive study of the coal mining industry, should command the earnest interest of Congress and coal men.

A responsible representative of the miners in conference at the Union League Club was presented the Hammond recommendation and asked if the conferees would agree to its essential terms as a basis for settling the mine tie-up. The reply was that while they could not then express an opinion upon the recommendation, it would receive very careful consideration.

New Equipment Recommended for Pasadena Plant

The Municipal Light & Power Department, B. F. DeLanty, acting general manager, of the City of Pasadena, Calif., in the annual report for 1924-25 says:

> We anticipate that the peak load for 1925-26 will amount to more than we can carry on our 12,500-kva. unit. Our reserve in the old power house, which amounts to 6,222 kva., would not be sufficient to carry us over in case our 12,500-kva. unit should fail, which condition would be inevitable if the unit were kept in continuous operation. It, therefore, seems to be a bad policy to endeavor to operate our plant without having some reserve capacity planned for. I, therefore, recommend that we be permitted to draw plans and specifications for a new unit with a capacity of 20,000 kva. A place has been provided for the reception of such a unit, and our calculations show that we can install a unit of this character for very much less per kilowatt than the one we installed in 1923-24, as we would not have the expense of excavation, building, crane, etc.
>
> Along with this unit it will be necessary to purchase four 1,000-hp. water-tube boilers to make the plant complete, and as the best engineering practice shows that higher steam pressures are being employed, we also recommend that our steam pressure be increased from 250 to 300 lb. This increase will not interfere with any of the old equipment, as we can back this pressure down on the new boilers to suit the conditions of the equipment now installed.
>
> We have just completed the revamping of furnaces and equipping the two 1,000-hp. boilers with combination gas and oil burners and forced draft. The operating results from this form of fuel have been so much more satisfactory that we deem it advisable to change over the two 850-hp. boilers as soon as the material can be purchased and the work done.

Brooklyn Polytechnic Installs Dr. Kolbe as President

Dr. Parke Rexford Kolbe was inaugurated as president of the Polytechnic Institute of Brooklyn at an impressive and colorful ceremony on the evening of Jan. 13, 1926. About one hundred and seventy college presidents and representatives of learned societies, clad in black academic robes, with many-colored hoods designating their several distinctions, occupied the stage.

The Corporation of the Institute was represented by Dr. W. H. Nichols, its vice-president, and the faculty spokesman was the senior professor, Dr. G. S. Collins. Mr. Bancroft Gherardi spoke for the Alumni, and Mr. Edwin Zipse, of the senior class, for the student body.

Dr. C. A. Richmond, president of Union College and chancellor of Union University, spoke on behalf of the colleges, and emphasized the importance of increased attention to the moral aspects of education. Economic pressure in present-day industry, he declared, gives rise to lamentable clashes of interests for which the only adequate remedy is a greater moral pressure.

In referring to the unwieldy size to which some of our institutions of learning have expanded, he called attention to the fact that six hundred years ago the University of Paris numbered twenty thousand students, with thirty thousand at Oxford and Cambridge. However, he did not regard large numbers as good in themselves, and remarked that they may count for many but not for much.

After formally receiving the charter, keys and great seal of the Institute from Mr. C. E. Potts, Chairman of the Corporation, Dr. Kolbe discussed present-day educational problems, and advocated such modifications in current college organization as will foster a more thorough training of men of forthstanding ability and at the same time provide more valuable training for the great mass of students. The present plan attempts to force some men beyond their capacity and holds others below the level of their ability, with unfortunate results for both.

Dr. Parke Rexford Kolbe

Dr. Kolbe's experience in developing the Universities of Buffalo, N. Y., and Akron, Ohio, has given him a brilliant reputation, and the prospect for the Polytechnic Institute under his guidance is bright.

Mechanical Engineers Urged To Study Welding

The mechanical engineer who does not at once "get busy" learning the applications and methods of fusion welding, will find himself trailing the procession in a few years, according to speakers at a joint New York sections meeting of the A.S.M.E. and American Welding Society, held in the Engineering Societies Building on January 14, with A. G. Oehler, president of the American Welding Society, presiding. The meeting was addressed by the following prominent members of the A.W.S.: E. H. Ewertz, general manager of the Moore Plant, Bethlehem Shipbuilding Corp.; S. W. Miller, consulting engineer for the Union Carbide & Carbon Research Laboratory; William Schenstrom, welding engineer for the Electric Welding Company of America.

Mr. Ewertz gave a rapid review of the four main branches of fusion welding: electric arc, electric resistance, gas, thermit. Each of these, said Mr. Ewertz, had its special field, although there was some overlapping. He deplored the tendency of superintendents and designing engineers to entrust engineering decisions to unskilled and unguided welders. The man in charge should study the best way to handle each job. He outlined the principal processes.

The two main obstacles to the more rapid extension of welding, according to Mr. Ewertz, were the tendency to be guided by tradition and the lack of knowledge of fusion welding by the engineering fraternity. "Why shouldn't the engineers start getting this knowledge now," he said, "instead of waiting until they are forced into it?" He thought it particularly important for designers to understand welding and to design with welding in view.

The gas cutting torch was referred to by Mr. Ewertz as the most effective metal-cutting tool ever invented. Illustrative slides clearly brought out the different fields covered by thermit and gas welding, the former being particularly suited for the repair of breaks in heavy steel castings and similar work.

S. W. Miller, the next speaker, discussed "Welded Pressure Vessels," his remarks being directed particularly to the Unfired Pressure Vessel Code of the A.S.M.E. Boiler Code Committee.

He took the stand, in apparent agreement with many other members of the welding society, that the code limitations on welding were unduly severe and could not be defended on engineering grounds. He referred in particular to limitations on pressure, diameter and length of tanks and thickness of sheets. Welding, said Mr. Miller, could not be condemned just because incompetent welders might produce poor welds. Specifications of any sort assumed skilled workmanship. Mr. Miller presented a revised code for consideration of the Committee and of engineers in general.

Speaking unofficially for the Boiler Code Committee, V. M. Frost said that public comments had been sought on the code in advance, but that 95 per cent of the "kicks" came after its adoption. Both he and C. W. Obert, who spoke later, said the Code could grow as needed and that the Committee welcomed criticism from every source.

The importance of Mr. Miller's paper justifies a longer report, which it is hoped will be available soon.

William Schenstrom, the last speaker, discussed electric welding with particular reference to the fabrication of tanks, ships and pipes.

In a general discussion following the three addresses, one speaker, who was responsible for the welding in a tank manufacturing plant, spoke feelingly of the need for "conscience" in welders. He felt that many welders did not seem to realize the responsibility they were assuming in welding pressure vessels.

Crooked River, Ore., Studied by Geological Survey

At the request of the Federal Power Commission, the Geological Survey has made an investigation of the geologic conditions at all possible power sites on the Crooked River, the main tributary to the Deschutes River, Oregon.

The results of the investigation are given in an unpublished report entitled "Geological Examination of Dam Sites on Crooked River, Jefferson County, Oregon," by Harold T. Stearns, which is available for public inspection in the district office of the Geological Survey at 606 Post Office Bldg., Portland, Ore.

Florida Embargo Holds Up Power-Plant Construction

It is reported that the freight embargo to Florida, initiated by the various railroads is interfering with the construction of the new generating stations, which are in process of building, to such an extent that hundreds of men are idle awaiting the necessary materials to continue operation. It is understood that an appeal to the railroads will be made for priority in shipments of the necessary materials so that these public utilities may be started promptly to take care of the enlarged population of Florida.

Big Merger of Florida Power & Light Companies Announced

Formation of the Florida Power & Light Co., which will embrace nine operating utilities in Florida with aggregate assets of $80,000,000, was announced on Jan. 12 by the American Power & Light Co., which will own the stock of the new company.

Organization of the new company, of which S. R. Inch will be president, will consolidate under one management the following companies: Miami Electric Light & Power Co., Miami Gas Co., Miami Beach Electric Co., Southern Utilities Co., Daytona Public Service Co., Ormond Supply Co., Lakeland Gas Co., Johns Electric Co., and Southern Holding Co. It will supply electric power and light service to more than 60 communities.

Two new power stations which the company will acquire are under construction, one on the St. John's River, near Sanford, and the other on the New River, near Fort Lauderdale.

Appropriations Asked for Muscle Shoals Plant

The Chief of Engineers has asked for additional appropriations totaling $2,300,000 for the purchase of transformers and other expenses in connection with the Muscle Shoals power plant. The $3,040,390 already appropriated for this year's work did not provide for the purchase of the equipment necessary for the transmission of power away from Muscle Shoals. The transformers now in use were borrowed from the Alabama Power Company.

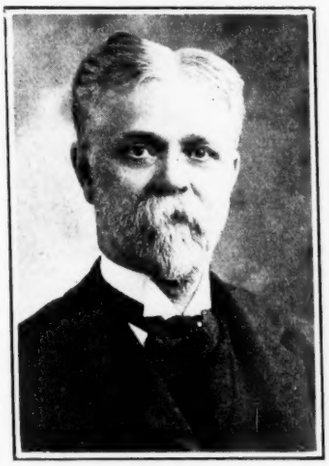
In his application for the additional money General Taylor points out that all the equipment should be owned by the government in order to enable it to dispose of the power to the greatest advantage, pending the disposition of the property by Congress.

Of the amount asked, $1,600,000 is for the transformers and their accessories and to cover the expense of their installation. Other items necessary to the completion of the plant call for an additional $400,000.

For the operation and maintenance of the power plant $300,000 is asked. The $1,000 daily which has been received for several months for the power sold, is not available for operating expenses. All receipts go directly into the United States Treasury.

Former President of Smooth-On Dies

Samuel D. Tompkins, a resident of Jersey City for over half a century, died at the old homestead, 533 Communipaw Ave., Jersey City, on New Year's



Samuel D. Tompkins

Day, 1926. Born in Hyde Park, Dutchess County, N. Y., in 1838, he was a former president of the Smooth-On Manufacturing Company, which was established in 1895. He was also an elder in the Bergen Reformed Church, Jersey City, and a member of the Seredatha Lodge No. 141 F. & A. M. Two daughters and three sons survive him.

Greer College Buys U. S. Electrical School

The Greer College of Chicago has recently purchased from the United States Government the Veterans Bureau's electrical trade school on Karlov Ave., Chicago, Ill. This is one of the most completely equipped electrical trade schools in the country and cost the United States Government $250,000 to equip and install.

Greer College has moved this equipment into its establishment and has engaged the government's former leading instructor, who with assistants is now prepared to give instruction in practical electricity, direct and alternating current, high-tension lines, house wiring, armature wiring, motors, generators, etc., in fact, everything necessary to enable a man to become an expert electrician.

Quebec Still Hostile to Export of Power

That the province of Quebec is still stoutly opposed to the exportation of power to the United States was clearly set forth in the speech from the Throne delivered at the opening of the legislature on Jan. 7.

The speech contained the definite statement that the government intended to continue its policy of prohibition in the matter of export. This is to take the form of permanent legislation which will be introduced in Parliament at a later date. Care was taken in the speech, however, to point out that the prohibition does not apply to the sister provinces.

Rhode Island's Governor Asks for Better Boiler Laws

In the annual message of Aram J. Pothier, Governor of the State of Rhode Island and Providence Plantations, to the General Assembly, at its January Session, 1926, the following recommendation in regard to the boiler laws was made:

The "Mackinac" disaster, due to the explosion of a steam boiler, which occurred within the limits of our state last summer, resulting in a heavy toll of lives and personal injuries to many of the survivors, brings forcibly to the mind the urgency of surrounding our people with every safeguard to prevent the recurrence of accidents of this nature, whether on land or on the waters of our state. I deem it of most importance that the present law relating to the fixing of a standard of construction and inspection of boilers be amended to give more ample protection to the general public, especially those who are daily in close proximity to steam boilers and other pressure vessels.

The inspector of steam boilers of the state should have jurisdiction over all boilers in the state. He should have a complete record and a report of the condition of the same made annually, including information as to where they are located while in operation. He should be notified when they are sold or removed and as to their final destination. He should be authorized to make an investigation of all accidents to boilers and pressure vessels, which should be reported to him at once by the owners, to determine the cause and aid the Attorney General's Department to fix the responsibility for neglect or carelessness.

No person should operate a boiler without having a certificate of competence issued, or erect or install a boiler without a permit from the boiler-inspection department, the inspector issuing a certificate after an inspection has been made by either his department or by an authorized inspector employed by an insurance company.

No one should be permitted to make an inspection or examination of a boiler unless he has a certificate of competence or a commission from the State Boiler Inspection Department or the National Board of Boiler and Pressure Vessels Inspectors.

Unfired Pressure Vessels Should Be Included in Laws

The law should also be amended to include all unfired pressure vessels as listed in the American Society of Mechanical Engineers Boiler Code, as there are many accidents occurring from the same with loss of life or injuries nearly as serious as those of boiler accidents.

The inspector should have the authority from the state to ascertain the condition of boilers or vessels plying in the waters within the state and adjacent waters continually, and protest the operation of the same if they are taken elsewhere for inspection or if the condition of the boiler is not satisfactory to him.

I most earnestly recommend that the General Assembly, early in the present session, devote careful consideration to this subject and that legislation be adopted providing for the most careful attention on the part of the state to the construction and inspection of steam boilers, other pressure vessels and mechanical devices which possess potential elements of danger to human life.

Power Generating Machinery Used in Brazil

In a series of articles on the Brazilian Machinery Market, *Commerce Reports* states that the central part of Brazil, which comprises the States of Sao Paulo, Rio de Janeiro, Parana, parts of Santa Catharina and Minas Geraes, owing to the large amount of water power available uses electricity to a great extent. Extending north from the electrified city of Bahia which includes the large sugar-producing states of Bahia and Pernambuco, steam is used almost exclusively, very little hydro-electric power being developed. The States of Alagoas, Rio Grande do Norte and Ceara use in the order of their importance, gas-producer engines, Diesel engines, and kerosene, gasoline and alcohol engines.

The difficulty of getting a constant supply of fuel oil, however, is an obstacle in the way of greater utilization of internal-combustion engines, and steam is the principal source of energy.

The steam plant is the leading prime mover in the southern district, comprising Rio Grande do Sul and parts of Parana and Santa Catharina. Gas-producer plants and Diesel engines, however, are also found here in large numbers. Rio Grande do Sul and Santa Catharina are the principal coal-producing states, and domestic fuel therefore is used to a considerable extent, particularly in the former, where large quantities are consumed by the railways. This zone is also rich in water power and a large number of isolated hydro-electric power plants are in operation. Nearly all the factories and mills, however, even in the larger cities, have their own individual plants instead of taking their power from a central station, as is the case with the central zone.

Turbines are not used to a great extent, and such as are imported come from Germany. Prices of the German makes are about 30 per cent less than those quoted by the American factories.

Engines Purchased from the United States

Few Diesel or semi-Diesel engines are employed owing to the plentiful supply of electric power and the fact that it is difficult, because of high transportation charges, to get fuel oil cheaply except in the large port cities. Until recently, practically no American Diesel or semi-Diesel engines were sold in Brazil, the majority being Swiss or German, with a few British. Because of the long dry spell experienced this year in Sao Paulo, the supply of hydro-electrical power became very low, and many of the factories were forced to operate for short periods of two to three days a week. A number of manufacturers, therefore, placed rush orders for steam and Diesel engines, and many of those orders went to the United States.

The greater part of the internal-combustion engines used in Brazil are of the single-cylinder, water-cooled, horizontal type with high-tension magneto and throttling governor. They are mostly of American origin. A large number of German vertical air-cooled engines trade-marked "Otto" have also been sold. In general, the horsepower of the majority of engines is from 1½ to 20, while in the rural districts 1½ to 4 is preferred.

Western Electrical Inspectors Announce Program

A round-table discussion on "The Solution of the Fuse-Abuse Problem" will be one subject in the program tentatively adopted for the twenty-first annual meeting of the Western Association of Electrical Inspectors at the Hotel Sherman, Chicago, on Jan. 26-28. This discussion, which will be held on Tuesday afternoon, Jan. 26, will be started as follows:

"Contribution of the Engineer: Special Design Branch Circuit Fuses," William P. Briggs, New Bedford, Mass.

"Contribution of the Central Station: Sealed Service Fuses," Joseph C. Langdell, Jackson, Mich.

"Contribution of the Manufacturer: Convenient Re-fusing Together with Instruction Labels at Cabinet," H. J. L. Frank, Detroit.

On Wednesday and Thursday these addresses will be made:

Wednesday Afternoon.—"Code Revision Procedure," A. R. Small, chairman electrical committee, National Fire Protection Association; "Recent Progress Toward Uniform Use of the National Electrical Code," W. J. Canada, field secretary electrical committee, National Fire Protection Association; "The Uniform Electrical Ordinance," Harry B. Kirkland, Society for Electrical Development; "The Work of Local Code Committees," A. Penn Denton, Association of Electragists International; "Safety with Economy," Lawrence W. Davis, manager, Association of Electragists International.

Thursday Afternoon.—"Electrical Work at the Bureau of Standards," Dr. M. C. Lloyd; "Attitude of Electrical Industry Toward the Electrical Inspector," Earl E. Whitehorne, commercial editor, *Electrical World*; "Reinspection," S. B. Williams, editor *Electragist*, New York.

Society Affairs

The Metropolitan Section of the A.S.M.E. will hold a meeting on Feb. 24, at which "Boiler Tube Corrosion" will be the subject considered. Members of the Founders Societies will be welcome.

The Metropolitan Section of the A.S.M.E. will consider the subject of the "Distillation of Coal," at its meeting on Feb. 24. Members of the A.S.C.E., A.I.E.E. and A.I.M.M.E. are invited to attend this meeting.

The Diesel Engine Users Association, 19 Cadogan Gardens, London, S. W. 3, has recently elected officers for 1926. E. W. Johnston was elected president; F. A. Greene and C. F. Moundsdon have been elected to fill the vacancies on the general committee; Percy Still and Geoffrey Porter have been re-elected joint honorary secretaries.

The Philadelphia Section of the Association of Iron and Steel Electrical Engineers will hold a meeting at the Engineers' Club, 1317 Spruce St., on Feb. 6. "Power Rates," will be the subject of the evening, and D. M. Petty, superintendent of the electrical department, Bethlehem Steel Co., Lehigh Light Plant, will speak on "Purchased Power Rates," and R. L. Baker, manager, industrial power service, Metropolitan Edison Co., Reading, Pa., will speak on "Utility Power Rates and an Analysis of Rate Structure."

The Baltimore Section of the A.I.E.E. will have as the attraction for the Feb. 19 meeting, which will be held at the Johns Hopkins University, "Mercury-Arc Rectifier as Applied to Power Development," by H. D. Brown, General Electric Co.

Personal Mention

N. I. Garrison has been appointed assistant to Frank J. Meyer, assistant to the general manager in charge of operation of the Oklahoma Gas & Electric Co., with office at Oklahoma City.

John C. Bannister, vice-president in charge of engineering of the Walworth Co., Boston, Mass., was given a farewell dinner at the Harvard Club in Boston recently. Mr. Bannister decided to retire from active work, although he is still to be "on call," it was brought out at the dinner. He announced "that he hoped to soon be able to turn in a golf score somewhere down in the 70's."

Business Notes

The Edward Valve & Manufacturing Co., announces that its New Haven, Conn., representative is now at 914 Chamber of Commerce Bldg.

The Maxim Silencer Co., Hartford, Conn., manufacturer of silencers for industrial machinery, has appointed W. C. Whitney, formerly of the Brunswick-Kroeschell Co., New Brunswick, N. J., as sales manager.

The C. H. Wheeler Manufacturing Co., Lehigh & Sedgley Aves., Philadelphia, Pa., announces that B. K. Mould will be in charge, beginning with Jan. 1, of its New York office at 50 Church St., and W. W. Clinedinst will be associated with him.

The G. K. McMullen Co. is the name of a newly organized company which will act as a direct factory representative for machinery manufacturers in the territory of western, central and northern Michigan. The address of the company is 201 McMullen Bldg., 19-27 Division Ave., S. W., Grand Rapids, Mich.

Charles T. Main, engineer, 200 Devonshire St., Boston, Mass., announces that Marcus K. Bryan and R. A. Moncrieff, who have been connected with the organization for some time became associates on Jan. 1, in addition to the following: F. M. Gunby, H. E. Sawtell, J. F. Osborn, W. F. Uhl, C. R. Main, A. W. Benoit.

The Drake Non-Clinkering Furnace Block Co., 5 Beekman St., New York City, announces changes in its organization: Alfred Campbell, formerly district representative in the Pittsburgh and Cincinnati territories, has been appointed general manager; Harry Baumgartner, formerly with the Public Service Co. at Essex Station, has been retained as refractory engineer; D. B. Wilson, who has been appointed district sales representative in Philadelphia, is also in charge of the Baltimore and Washington, D. C., territories.

The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., at a recent meeting of its executive committee, elected S. L. Nicholson as acting vice-president. Mr. Nicholson has been associated with the Westinghouse company since 1898.

The National Valve & Manufacturing Co., Pittsburgh, Pa., announces the appointment of the Ernest E. Lee Co., merchant engineers, 115 South Dearborn St., Chicago, Ill., as district representative to cover the State of Illinois, south to Springfield, eastern Ohio, southern Wisconsin and northern Indiana.

The Link Belt Co., 910 South Michigan Ave., Chicago, Ill., announces the creation of a new position, that of chief engineer of the company, which is being filled by W. W. Sayer, formerly chief engineer of the Philadelphia plant. George L. Morehead takes on the duties of manager of the Philadelphia plant. The company also announces the opening of a branch office in the First Wisconsin National Bank Bldg., Milwaukee, Wis., with R. C. Kendall in charge.

The Electric Service Supplies Co., Chicago, Ill. has announced appointments of sales representatives: C. V. Root will cover the Chicago territory in the interest of floodlighting; G. R. Scott will cover Minnesota, North and South Dakota, Iowa and eastern Nebraska; Charles J. Brickley will take charge of Wisconsin and upper Michigan; L. S. Belding will cover Ohio and parts of Michigan; J. F. Carper has joined the steam-railroad department of the company.

The S. Morgan Smith Co., York, Pa., has successfully defended its right to the use of plate-steel scroll cases, in the suit brought by the Allis-Chalmers Manufacturing Co., against the Columbus Electric & Power Co. The suit was decided by the United States District Court for the Northern District of Georgia. Three installations were mentioned in the suit: The Mountain King Mining Co., of California, 1914; the Goat Rock development of the Columbus Electric & Power Co., 1919; the Bartlett Ferry development of the Columbus Electric & Power Co., 1925.

The General Electric Co., Schenectady, N. Y., announces recent appointments: A. S. Durant, formerly manager of the department of the Americas, has been made a vice-president of the International General Electric Co. in charge of commercial relations, with headquarters in New York City; James C. Ryan, formerly sales manager of the department of the Far East, has been appointed general sales manager with responsibility for all sales of apparatus and supplies; E. A. Baldwin, formerly manager of the department of Europe, has been appointed manager of the Schenectady office, with responsibility for engineering and contact relations; W. J. Edmonds, comptroller of the company, with headquarters in New York City, in addition to his former duties, now has executive direction of the activities, with the exception of sales effort, of the International foreign sales companies; W. J. Foster, assistant engineer has been made a consulting engineer of the same or alternating-current engineering department.

Coming Conventions

American Boiler Manufacturers Association. D. W. Glanzer, 840 Rockefeller Bldg., Cleveland, Ohio. Meeting at Mid-Day Club, Cleveland, Ohio, Feb. 12

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Convention at Engineering Building, New York City, Feb. 8-12.

American Institute of Mining & Metallurgical Engineers. Dr. H. Foster Bain, 29 West 39th St., New York City. Annual meeting at Engineering Societies Bldg., New York City, Feb. 15-17.

American Oil Burners Association. Leod D. Becker, 350 Madison Ave., New York City. Annual convention and exposition at Book Cadillac Hotel, Detroit, Mich., April 6-8.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Convention at Haddon Hall, Atlantic City, N. J., June 21-25.

American Society of Civil Engineers. George T. Seabury, 29 West 39th St., New York City. Annual meeting at New York City, Jan. 20-22.

American Society of Heating & Ventilating Engineers. F. C. Houghten, 29 West 39th St., New York City. Annual meeting at Hotel Statler, Buffalo, N. Y., Jan. 27-29.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Spring convention at San Francisco, Calif., June 28-30.

Association of Municipal Electric Utilities. S. R. A. Clements, 190 University Ave., Toronto, Canada. Convention at Toronto, Ont., Jan. 27-28.

Engineering Institute of Canada. Richard John Durley, 176 Mansfield St., Montreal, Que. Annual meeting at Toronto, Ont., Jan. 27-29.

Heating & Ventilating Exposition. E. P. Frenz, Hotel McAlpin, New York City. Exposition at new Madison Square Garden, New York City, Mar. 17-23.

Iowa Engineering Society. J. S. Dodds, Box 202, Ames, Iowa. Convention at Mason City, Jan. 27-29.

Master Boiler Makers Association. Harry D. Vought, 26 Cortlandt St., New York City. Annual convention at the Statler Hotel, Buffalo, N. Y., May 25-26.

Midwestern Engineering Exposition, Inc. George E. Pfisterer, 53 West Jackson Boulevard, Chicago, Ill., general manager. Exposition and power show to be held in Chicago, American Exposition Palace, Jan. 26-30.

National Electric Light Association. A. Jackson Marshall, 29 West 39th St., New York City. Forty-ninth convention and manufacturers' exhibition, at Atlantic City, Young's Million Dollar Pier, May 17-21.

Power Show. International Textile Exposition—James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show will be Department "D" of the International Textile Exposition, and will be under the auspices of the New England Association of Commercial Engineers, and held at the Mechanics Bldg., Boston, Mass., April 12-17.

Sesquicentennial International Exposition. Capt. Asher C. Baker, director in chief. Independence Square, Philadelphia. Exposition to be held in Philadelphia, Pa., from June 1 to Dec. 1.

Society of Automotive Engineers. Coker F. Clarkson, 29 West 39th St., New York City. Annual meeting at the General Motors Bldg., Detroit, Mich., Jan. 26-29.

Western Association of Electrical Inspectors. W. S. Boyd, 175 West Jackson Blvd., Chicago, Ill. Meeting at Hotel Sherman, Chicago, Ill., Jan. 26-28.

Trade Catalogs

Safety Hand Lamps — Crouse-Hinds Co., Syracuse, N. Y. Bulletin covering safety hand lamps for use in difficult and out-of-way places.

Valves—Hydraulic Press Manufacturing Co., Mount Gilead, Ohio. Bulletin No. 4309 covers "the H.P.M." forgsteel straightway valve for high temperature, high pressure and high superheat only.

Celite—Celite Products Co. Bulletin 314, which has recently been issued by the company, shows the advantages of the mixing of "Celite" in concrete for use in building dams, bridges, buildings, industrial plants, railroads and other structures.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; **mine run** except Pittsburgh gas slack:

Bituminous. Net Tons	Market Quoting	Jan. 11 1926
Pool 1	New York	$2.75@$3.15
Smokeless	Boston	2.10
Clearfield	Boston	1.75@ 2.10
Somerset	Boston	1.90@ 2.25
Kanawha	Columbus	1.55@ 1.85
Hocking	Columbus	1.75@ 2.00
Pittsburgh	Pittsburgh	2.00@ 2.10
Pittsburgh gas slack	Pittsburgh	1.50@ 1.60
Franklin, Ill.	Chicago	2.35@ 2.65
Central, Ill.	Chicago	2.25@ 2.35
Ind. 4th Vein	Chicago	2.25@ 2.35
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.40@ 1.75
Big Seam	Birmingham	2.00@ 2.25
Anthracite. Gross Tons		
Buckwheat No. 1.	New York	$2.50@$2.75
Buckwheat No. 1.	Philadelphia	2.50@ 3.00
Birdseye	New York	....

FUEL OIL

New York—Jan. 14, light oil, tank-car lots; 28@34 deg. Baumé, 5¼c. per gal.; 36@40 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Jan. 5, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.05 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.15 per bbl.; 30@32 deg., $2.20 per bbl.; 32@36 deg., gas oil, 5.5c. per gal.; 38@40 deg., 6¼c. per gal.

Pittsburgh—Jan. 5, f.o.b. local refinery; 30@34 deg., fuel oil, 5¾c. per gal.; 36@40 deg., fuel oil, 6¼c. per gal.

Dallas—Jan. 13, f.o.b. local refinery; @6@30 deg., $1.55 per bbl.

Philadelphia—Jan. 8, 27@30 deg., $2.31@$2.37 per bbl.; 18@22 deg., $1.75@$1.81; 13@19 deg., $1.68@$1.74 per bbl.

Boston—Dec. 21, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4.55c. per gal. light oil, 28@32 deg. Baumé, 5¾c. per gal.

Cincinnati—Jan. 12, tank-car lots, f.o.b. local refinery, 24@26 deg., Baumé, 6¾c. per gal.; 26@30 deg., 7c. per gal.; 30@32 deg., 7¼c. per gal.

Chicago—Jan. 12, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.30 per bbl.; 26@30 deg., $1.35; 30@32 deg., $1.40@$1.45.

New Plant Construction

Calif., Carmichael—Carmichael Irrigation Dist. is receiving bids for furnishing and installing pipe and auxiliary apparatus including three 75 kv. transformers. Estimated cost $30,000. A. Givan, City Hall, Sacramento, is engineer.

Calif., Los Angeles—H. H. Albernathy, Wilcox Ave. and Hollywood Blvd., awarded contract for the construction of a 13 story hotel including swimming pool, etc., to L. A. Housing Corp., Black Bldg. Estimated cost $1,500,000.

Colo., Denver—Bureau of Reclamation, Dept. of the Interior, will receive bids until Feb. 19 for furnishing 15 radial gates and 15 motor driven gate hoists for American Falls dam, Minidaka, Idaho, 6 radial gates and 6 double drum hoists for McKay dam, Umatilla, Ore.

Ill., Chicago — Holabird & Roche, 104 South Michigan Ave., Archts., will receive bids until Jan. 21 for the construction of a 36 story office building for Roanoke Building Corp., 129 West Madison St. Estimated cost $3,000,000.

Ill., Chicago — Michigan-Lake Building Corp., c/o F. T. Hoyt, Pres., 160 North La Salle St., will soon receive bids for the construction of a 22 or 23 story office and stores building at Lake St. and North Michigan Ave. A. S. Alschuler, 28 East Jackson Blvd., is architect.

Ill., Chicago—Oldefest & Williams, 695 North Michigan Ave., Archts., is receiving bids for the construction of a 10 story apartment at Dearborn and Maple Sts., for Landsboro Hotel Corp., J. M. Lansinger, Pres., 1527 Juneway Terrace. Estimated cost $500,000.

Ill., Chicago—M. S. Plotke, 111 West Washington St., is having plans prepared for the construction of a 20 story bank and apartment building at Rush and Ontario Sts. Estimated cost $2,750,000. Huszagh & Hill, 6 North Michigan Ave., are architects.

Ill., Chicago—Schmidt, Garden & Martin, 104 South Michigan Ave., Archts., are receiving bids for the construction of a 12 story apartment at 5344-5348 Cornell Ave., for F. L. Holzer, 29 South La Salle St.

Ill., Golconda—City awarded contract for the construction of a pumping station, two water towers, storage basin, two deep wells, etc., to E. K. Ladd, Peotone, $139,000.

Ill., Rockford—City plans the installation of a 3,500 cu.ft. steam driven air compressor, two additional deep wells with conduits and air lines, also extensions to distribution mains, etc., at West End pumping plant. Estimated cost $100,000. B. C. Harvey, City Hall, is engineer.

La., Monroe—The Ouachita Baking Co. plans the installation of a refrigeration plant in connection with proposed new building.

La., Morganza—Bd. of Alderman, R. C. Dawson, will receive bids until Jan. 21 for the construction of a waterworks system, including crude oil engine, centrifugal pump, reservoir, tank on tower, etc. Swanson-McGraw, Inc., United Fruit Bldg., New Orleans, is engineer.

La., Thibodaux—Thibodaux Ice & Mfg. Co., P. R. Perry, Pres. and Mgr., plans to expend from $25,000 to $30,000 for the installation of refrigeration machinery for the manufacture of raw water ice. G. E. Brown, St. Louis, Mo., is superintendent of installation.

La., White Castle—City voted $28,000 bonds for the construction of a new waterworks system and light plant.

Mich., Detroit—J. B. Book, Jr., Book Bldg., Washington Blvd., plans the construction of a 22 story bank and office building including steam heating equipment at Washington Blvd. and Grand River Ave. Estimated cost $2,000,000. Architect not announced.

Mich., Detroit—Public Lighting Comn., 174 East Atwater, awarded contract for the construction of switching stations A.C. and D. on Potter St., Custer Ave. and Luden St. to W. H. Mueller, 2210 Park Ave. $373,000.

Mich., Detroit—F. Wardell, Dewey and Hamilton Ave., will soon award contract for the construction of a 12 story hotel, including steam heating equipment at Kirby and Woodward Aves. Estimated cost $2,500,000. Weston & Ellington, 507 Stroh Bldg., are architects and engineers.

Miss., Columbus—Columbus Ice & Creamery Co., c/o D. S. Cox, College and Sixth Sts., plans the installation of two 12 ton refrigeration machines, and other machinery to replace fire loss. Estimated cost $60,000.

Miss., Hattiesburg—Firm Lumber Co., C. Z. Stevens, Pres., awarded contract for the construction of a 50-ton raw water ice manufacturing plant to Vitter Mfg. Co., 935 Clinton St., Milwaukee, Wis. Estimated cost $100,000.

Missouri—Missouri Farmers Association, Inc., H. A. Cowden, Secy., Columbia, is having preliminary plans prepared for the construction of a cold storage plant. Estimated cost $150,000.

Mo., Kansas City—The Pan American Feed Co., J. O. Patterson, Pres., 615 Ridge Bldg., will soon receive bids on boilers, pumps, condensers, evaporators, electric motors, pulverizers, feed mixers, etc., for proposed garbage disposal plant at 25th St. and State line. Estimated cost $220,000. F. L. Wealkey, 501 Sharp Bldg., is consulting engineer and industrial architect.

Mo., St. Louis—St. Louis Independent Packing Co., 3825-3833 Chouteau Ave., awarded contract for the construction of addition to packing plant to McKelvey Construction Co., Title Guaranty Bldg. Estimated cost $250,000. Packing house machinery, conveyors, etc., will be installed.

Neb., Dawson—Village, C. W. Kimsey, Clk., will receive bids until Jan. 22 for the construction of a waterworks system, including a 6 x 8 single acting triplex plunger pump, 125 g.p.m., 45 crank r.p.m., 15 hp. single ph. 220 v., 1200 r.p.m. a.c. motor. Estimated cost $15,000. Henningson Engineering Co., Twelfth and Harney Sts., Omaha, is engineer.

N. Y., Brooklyn—Gold Seal Laundry, 962 Franklin Ave., is having plans prepared for the construction of a power house on Atlantic Ave. Estimated cost $165,000. Shampan & Shampan, 188 Montague St., are engineers.

N. Y., New Rochelle—Odell Construction Corp., c/o L. E. Denslow, 44 West 18th St., New York, Archt., is having plans prepared for the construction of a six story apartment at Odell Place. Estimated cost $500,000.

N. Y., New York—R. Brown c/o Shape, Bready & Peterkin, 50 East 42nd St., Archts., is having plans prepared for the construction of a 15 story apartment on East 86th St. Estimated cost $750,000.

N. Y., New York—C. S. & K. Construction Co., Inc., 19 West 44th St., plans the construction of a 20 story apartment at 331-341 West 86th St., here. Estimated cost $2,000,000. W. I. Hohauser, 1400 Broadway, is architect and engineer. Work will be done by separate contracts. Address F. Leder, 188 Montague St., Brooklyn.

N. Y., New York—Central Park & Sixty First Street Corp., H. B. Rubin, c/o E. Roth, 119 West 40th St., Archt. and Engr., is having plans prepared for the construction of a 20 story apartment at Central Park West and Sixty First St. Estimated cost $3,000,000.

O., Cleveland—Graham, Anderson, Probst & White, 80 East Jackson Blvd., Chicago, Ill., Archts., will receive bids until Jan. 20 for the construction of the first section of a 52 story tower building, including central heating plant for Cleveland Terminals Building Co., 323 Lakeside Ave., Cleveland, Ohio.

O., Dayton—G. F. Baker, Dir. of Public Service, will receive bids until Jan. 29 for the construction of a new pumping station. Estimated cost $75,000. W. W. Morehouse, is superintendent of waterworks. Metcalf & Eddy are consulting engineers.

O., Gallipolis—Logan Furniture Co., E. Ferguson, Pres., is in the market for two 100 hp. boilers for plant to replace those condemned.

Okla., Collinsville—City is having preliminary plans prepared for the installation of 3 new high pressure boilers in municipal pumping station. Estimated cost $30,000. Holway Engineering Co., 505 New Wright Bldg., Tulsa, is engineer.

Pa., Philadelphia—Dept. of Public Bureau of Engineering will receive bids until Jan. 20 for the construction of sewers and pumping station in connection with South Philadelphia improvement district at Packer Ave. and West Broad St.

R. I., Providence—Fruit & Produce Association, W. S. Street, Pres., is having plans prepared for the construction of a group of buildings, including a cold storage and refrigeration plant, etc., on Allens Ave. Estimated cost $2,500,000. T. J. Hill Pierce, Inc., 30 Allens Ave., is architect. Refrigerating machinery will be required.

S. D., Willow Lake—City plans the construction of a waterworks system, including sinking of deep wells, the installation of pumping equipment and distribution mains, etc. Estimated cost $20,000. Engineer not announced.

Tenn., Nashville—City will receive bids until Jan. 22 for three 500 hp. water tube boilers with superheaters. J. N. Chester, Union Bank Bldg., Pittsburgh, Pa., is engineer.

Tenn., Nashville—Nashville Warehouse & Elevator Corp., awarded contract for the design and construction of a 360,000 bu. grain elevator, including 10 circular tanks, 24 ft. in diameter, complete with head house, loading and unloading belts to Stevens Engineering & Construction Co., Seventh and Market Sts., St. Louis, Mo. All machinery will be individually motor driven.

Tex., Paducah—West Texas Utilities Co., Abilene, has recently purchased the Paducah light plant and is having surveys made for extensions here. Private plans. New machinery, etc., will be required.

Tex., Pharr—M. H. Lowrie & D. McClenton plan the construction of a cold storage plant. Estimated cost $25,000. Private plans. Machinery will be required.

Tex., Sherman—Pool Knitting Mills, C. Pool, Pres., plans to expend $10,000 for machinery, motors, etc., for knitting mill. Private plans.

Wis., Antigo—D. D. Korth plans the construction of a cheese factory and creamery. Estimated cost $40,000. Architect not selected. Refrigeration, boilers, engine, etc., will be required.

Wis., Madison—Bd. of Education, H. W. Pickford, Secy., West Dayton St., is receiving bids for the construction of a steam heating plant including boilers for new East Side High School. Estimated cost $25,000. Private plans.

Wis., Pittsville—Pittsville Canning Co., H. Schneider, Mgr., will build a cannery including power house, warehouse, etc., by day labor. Estimated cost $40,000. Private plans. Canning and conveying machinery and power boiler will be installed.

Wis., Saint Nazianz—Salvatorian Fathers is having preliminary plans prepared for the construction of a college including central power plant, laundry building, etc. Estimated cost $300,000. E. Brielmaier & Sons Co., 432 Broadway, Milwaukee, is architect. Boilers, etc., will be required.

Ont., Fort William — Hydro Electric Power Commission, 190 University Ave., Toronto, plans the construction of an outdoor sub-station here. Estimated cost $280,000. F. A. Gaby, 190 University Ave., Toronto, is engineer. Transformers, oil switches, switchboards, insulators, etc., will be required.

Ont., Peterborough—City is in the market for two 3 hp. electric motors connected to two centrifugal pumps for sewage pumping station.

Que., Cap-de-la-Madelaine—J. A. Nadeau is in the market for two 2½ hp. and three 5 hp. electric motors, belt chain, etc. Estimated cost $4,000.

Que., Quebec City—City plans the construction of a new pumping station. Estimated cost $90,000. F. C. Baillarge is engineer.

N. Z., Wellington—Public Works Supplies & Tenders Board, will receive bids until Mar. 23—for Arapuni Power Supply, Sect. 125—5 automatic oil immersed circuit breaker panels complete (transformer); 5 automatic oil immersed circuit breaker panels complete (feeder); 2 synchronous condenser panels complete, 4 non-automatic oil immersed circuit breakers, 1 metering desk complete with instruments for 5 feeders for Penrose substation. Arapuni Power Scheme, Sect. 154—4 oil filters 7 to 12 g.p.m., 1 25 to 40 g.p.m., 5 oil testing equipment, 5 filter paper drying ovens. Manahao Power Development, Sect. 182, No. 3 dam—1 automatic dam. Sect. 181, No. 3 dam—1 dam gate and 1 tunnel gate complete with controls.